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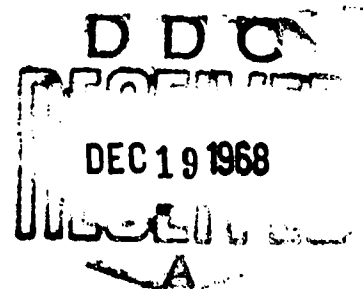
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AD 844920

FOURTH ANNUAL REPORT OF THE  
AIR FORCE MACHINABILITY DATA CENTER

John Maranchik, Jr.  
Metcut Research Associates Inc.

OCTOBER 1968



Advanced Fabrication Techniques Branch  
Manufacturing Technology Division  
Air Force Materials Laboratory  
Research and Technology Division  
Air Force Systems Command  
United States Air Force  
Wright-Patterson Air Force Base, Ohio

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*attn: MATF*

## FOREWORD

The Fourth Annual Report of the Air Force Machinability Data Center (AFMDC) covers work performed under Contract AF 33(615)-5262 from February 1, 1968 through September 30, 1968. The manuscript was released by the author in October 1968 for publication as an AFMDC report.

This contract with Metcut Research Associates Inc., Cincinnati, Ohio, was initiated under Manufacturing Technology Division Project 9-700, "Air Force Machinability Data Center". It was an extension of Manufacturing Technology Division Project 8-239 as indicated in our First, Second and Third Annual Reports. This contract was performed under the technical direction of Mr. Max A. Guenther of the Advanced Fabrication Techniques Branch (MATF), Manufacturing Technology Division, Air Force Materials Laboratory, Wright-Patterson Air Force Base, Ohio.

This project was accomplished as a part of the Air Force Manufacturing Methods Program. The primary objective of AFMDC is to be highly specialized in the collection, evaluation, storage, retrieval and dissemination of significant data and information pertaining to all aspects of material removal processes. Recipients of these data include aerospace industry, Department of Defense (including all of the military services and their contractors), and other Government agencies, technical institutions, and nonmilitary industries in a position to assist the defense effort. In the area of material removal activity, this Center serves as the communications link for the entire technical community, both Government and industry.

Your comments are solicited on the potential utilization of the Air Force Machinability Data Center as applied to your present or future production programs.

This report has been reviewed and is approved.



Jack R. Marsh, Chief  
Advanced Fabrication Techniques Branch  
Manufacturing Technology Division  
A F Materials Laboratory

## ABSTRACT

### FOURTH ANNUAL REPORT OF THE AIR FORCE MACHINABILITY DATA CENTER

John Maranchik, Jr.

This is the Fourth Annual Report of the Air Force Machinability Data Center covering period February 1, 1968 through September 30, 1968 (Contract AF 33 (615)-5262). Two thousand eight hundred and forty (2,840) documents were processed from which 13,833 cards were key punched. Currently, there are 15,941 evaluated documents and 116,083 punched cards in AFMDC files. Nine hundred and eighty two (982) specific inquiries were answered for 439 different companies, representing 596 individuals in 105 different SIC categories. The average of 123 inquiries per month is an increase of 46% over the average of 84 per month processed in the previous year.

The average cost of inquiries equaled \$58.58 per inquiry.

Two data products were completed and made available to the Center's users.

The data acquisition plant visit program was continued and since late 1966, 46 Visitations have been made, primarily to aerospace firms.

Computer programs have been developed and made operational for storage and retrieval of all the information files in use by the Center. In addition, a computer program has been made operational for investigating relationships between machining variables. Determination of existing relationships will be very valuable for evaluation of new data and filling in gaps in accrued data.

At the request of DoD, a report was prepared estimating the cost savings resulting from AFMDC's operation. For a 4-year period these savings were estimated to be \$37,800,000.00.

Plans for next year's effort call for augmenting current efforts and services. This includes identification of potential users of the Center and increased contact with them. This will be accomplished directly by AFMDC and through cooperation with other centers and State Technical Services Programs. This controlled effort will result in an increase in AFMDC inquiries from the current 123 per month rate to about 160 per month by October, 1969, consistent with the increasing capability of the Center. AFMDC will participate in Special Merit Projects with the States of Vermont and New York. The objectives are to establish access to information from Centers and transferring it to industry.

Four data products will be prepared and made available to users. Work will continue on the program for investigating relationships between machining variables. A study will be made concerning the potential and the required mechanisms by which users of the center may have a computer data-link with AFMDC.

## PREFACE

This report covers a 8-month period of operation from February 1, 1968 through September 30, 1968. It is presented primarily in the form of individual charts which are self-explanatory with regard to organization of the Center and the results of its efforts, including costs. For each individual chart, the Appendix provides some further comments concerning various aspects of AFMDC during its third year of operation.

For a complete analysis of the progress made by the Center from its early inception to the present, the following four references should be reviewed:

“Final Report on the Design of a System for Collecting, Evaluating and Disseminating Machinability Data for Aerospace Materials”, Technical Documentary Report Nr. ASD-TDR-63-572, July 1963, AD-416743.

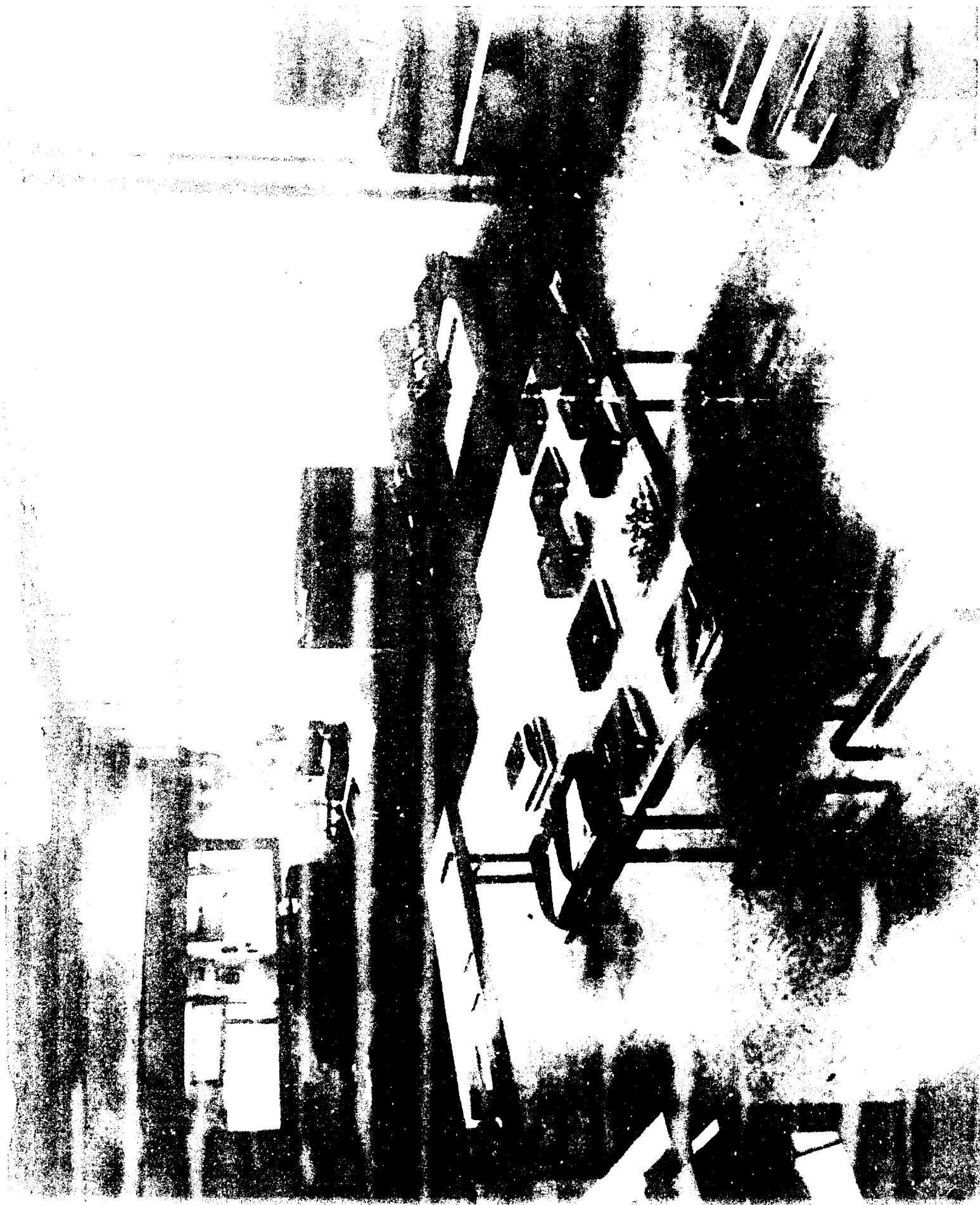
“First Annual Report of the Air Force Machinability Data Center”, AFMDC 65-2, February 1966, AD-482278.

“Second Annual Report of the Air Force Machinability Data Center”, AFMDC 66-4, February 1967, AD-813037.

“Third Annual Report of the Air Force Machinability Data Center”, AFMDC 67-8, February 1968, AD-829879.

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## DESCRIPTION OF AFMDC

AIR FORCE MACHINABILITY DATA CENTER, 3980 Rosslyn Drive, Cincinnati, Ohio 45209.  
Operated for the Air Force Materials Laboratory, Manufacturing Technology Division,  
under Contract AF 33(615)-5282, by Metcut Research Associates Inc.

### SCOPE

The Air Force Machinability Data Center (AFMDC) collects, evaluates, stores, and disseminates material removal information including specific and detailed machining data for the benefit of industry and government. Strong emphasis is given to engineering evaluation for the purpose of developing optimized material removal parameters, such as speeds, feeds, depths of cut, tool material and geometry, cutting fluids and other significant variables. Data are being processed for all types of materials and for all kinds of material removal operations such as turning, milling, drilling, tapping, grinding, electrical discharge machining, electrochemical machining, etc.

### COLLECTION

AFMDC has a mechanized system in which punch cards are used to store and retrieve all types of material removal information including all significant numerical data. An IBM 1130 computing system is being used for storing and processing data from a master card and disk file and for computer decoding. The focal concept for acquisition, interrogation, or presentation of information is the specific material (with definite chemical, physical, or mechanical properties) and the specific material removal operation being used. When necessary, card source control codes may be used to retrieve original documents which are in document storage at AFMDC.

### INFORMATION SERVICES

AFMDC places strong emphasis on providing specific and detailed answers to technical inquiries in the field of material removal. A User File, consisting of important users in the field of material removal, has been developed to receive information products including machining data pamphlets and tables on materials of current interest, state-of-the-art reports, technical announcements, and other appropriate items. Services are available without charge to the aerospace industry, Department of Defense (including all of the military services and their contractors), and other government agencies, technical institutions, and non-military industries in a position to assist the defense effort.

### TO REQUEST MACHINING INFORMATION . . . . .

Telephone: 513-271-8510  
TUX: 810-481-2840 or  
Write: Air Force Machinability Data Center  
3980 Rosslyn Drive  
Cincinnati, Ohio 45209

### TO HELP US ANSWER YOUR INQUIRY, IF POSSIBLE PLEASE:

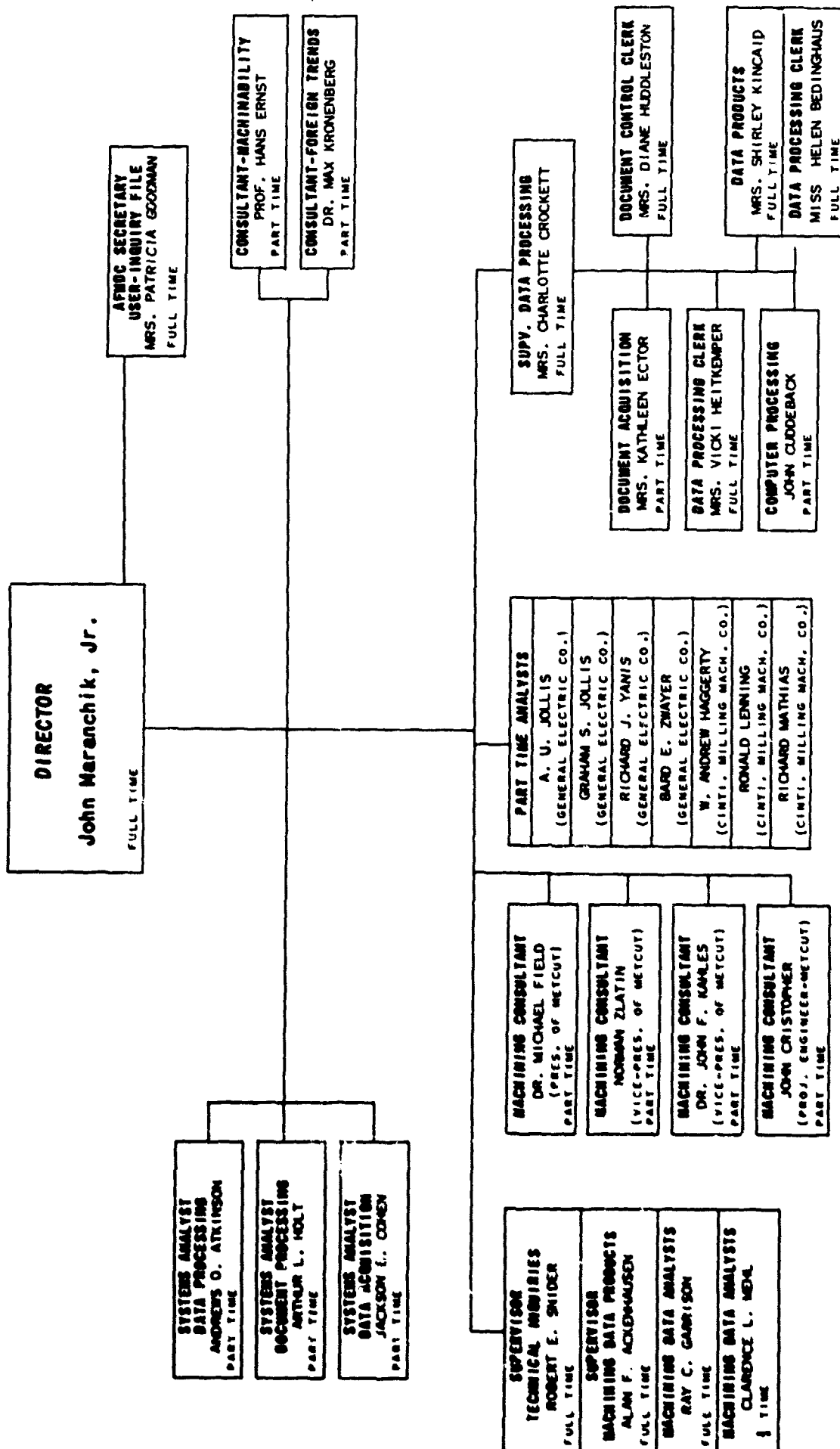
1. Identify the material being machined (*specification or tradename*); condition, (as cast, hot rolled, cold drawn, annealed, quenched and tempered, etc.); microstructure and hardness.
2. Identify the material removal operation in question (*turning, milling, drilling, tapping, surface grinding, electrical discharge machining (EDM), electrochemical machining (ECM), etc.*).
3. Specify reasons for requiring data unless your needs are proprietary. This enables AFMDC to broaden the scope of its technical advice.
4. Specify delivery requirements.
5. Indicate to whom the inquiry reply should be sent.
6. Transmit all details concerning present practices, including feeds, speeds, cutting tool material and geometry, cutting fluids, etc., in the event your inquiry pertains to improvement of an existing machining situation.

ooooo

NOTE: Association of the names of companies and individuals with specific requests is kept confidential. However, data developed remain the property of AFMDC for dissemination as required for answering similar inquiries and for developing data products.



# AFMDC ORGANIZATION CHART



Operated for the Air Force Materials Laboratory  
Manufacturing Technology Division under  
Contract 2F 33(615)-5262.  
by METCUT RESEARCH ASSOCIATES INC.

### AFMDC OPERATIONAL AREAS

At AFMDC, personnel shown in Figure 1, page 2, work in ten functional areas of operation. These are indicated below along with the numbers used for time coding purposes:

1	Administration	Administration of technical and general activities of AFMDC
2	Engineering Supervision	Technical activities including all mechanized handling of data and processing of inquiries
3	Systems Analysis	Design of the machinability data system, particularly processing
4	Machining Data Analysis	Technical evaluation of machinability data and information including Preliminary Screening
5	Data Processing	Operation of a mechanized system including a computer
6	Data Control	Superimposition and use of controls to guarantee proper operation of data processing system
7	Document Acquisition and Document Storage	Acquisition of all types of data and information for processing. Storage of documents including those which have received Final Technical Evaluation and those in process
8	Data Dissemination	Dissemination including duplication and printing
9	Machining Data Verification - Experimental Machining	Laboratory and shop work necessary for resolving highly significant and controversial data situations
0	Secretarial and Clerical	Development and execution of all procedures relating to typing and filing

# AFMDC OPERATIONS CHART

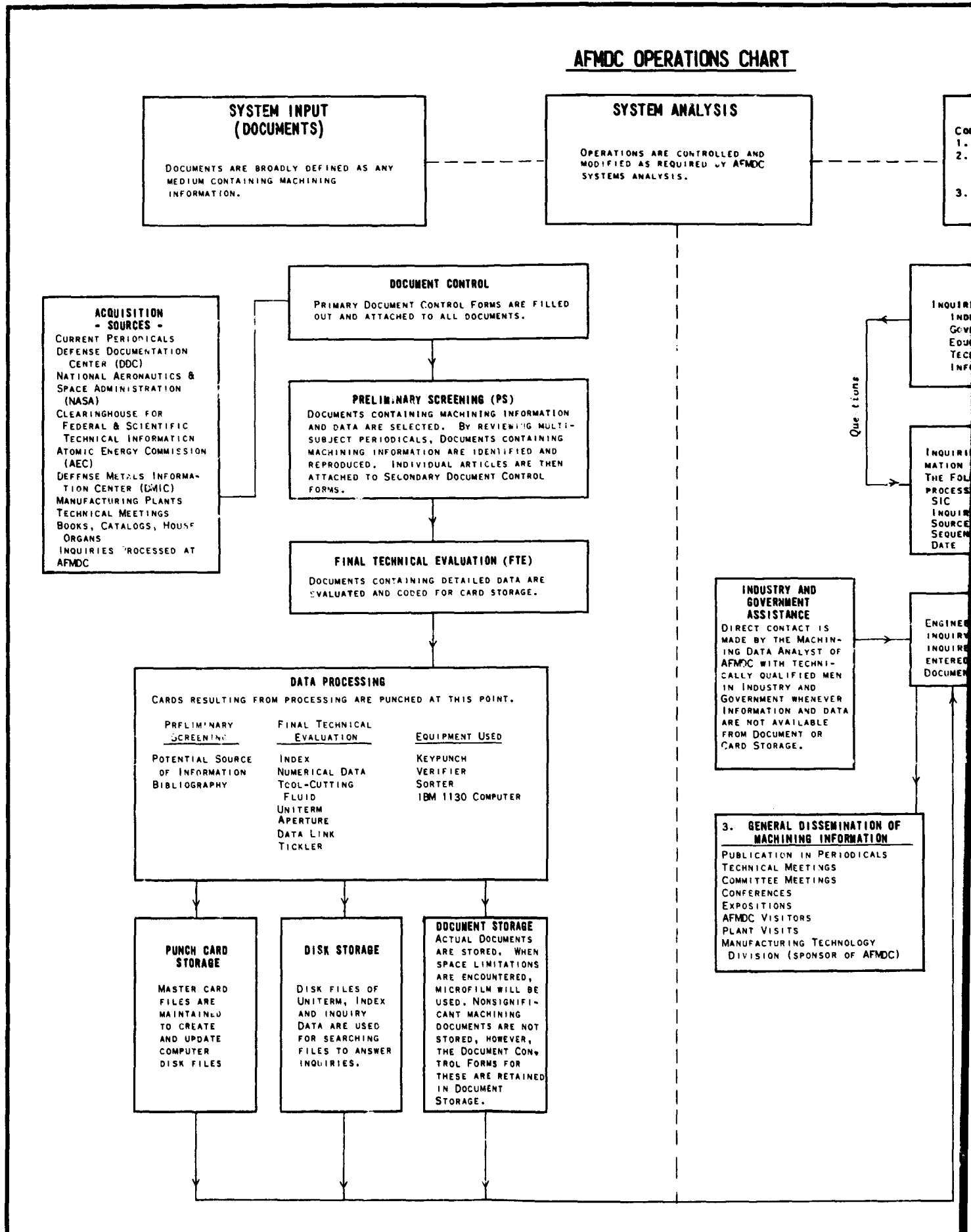
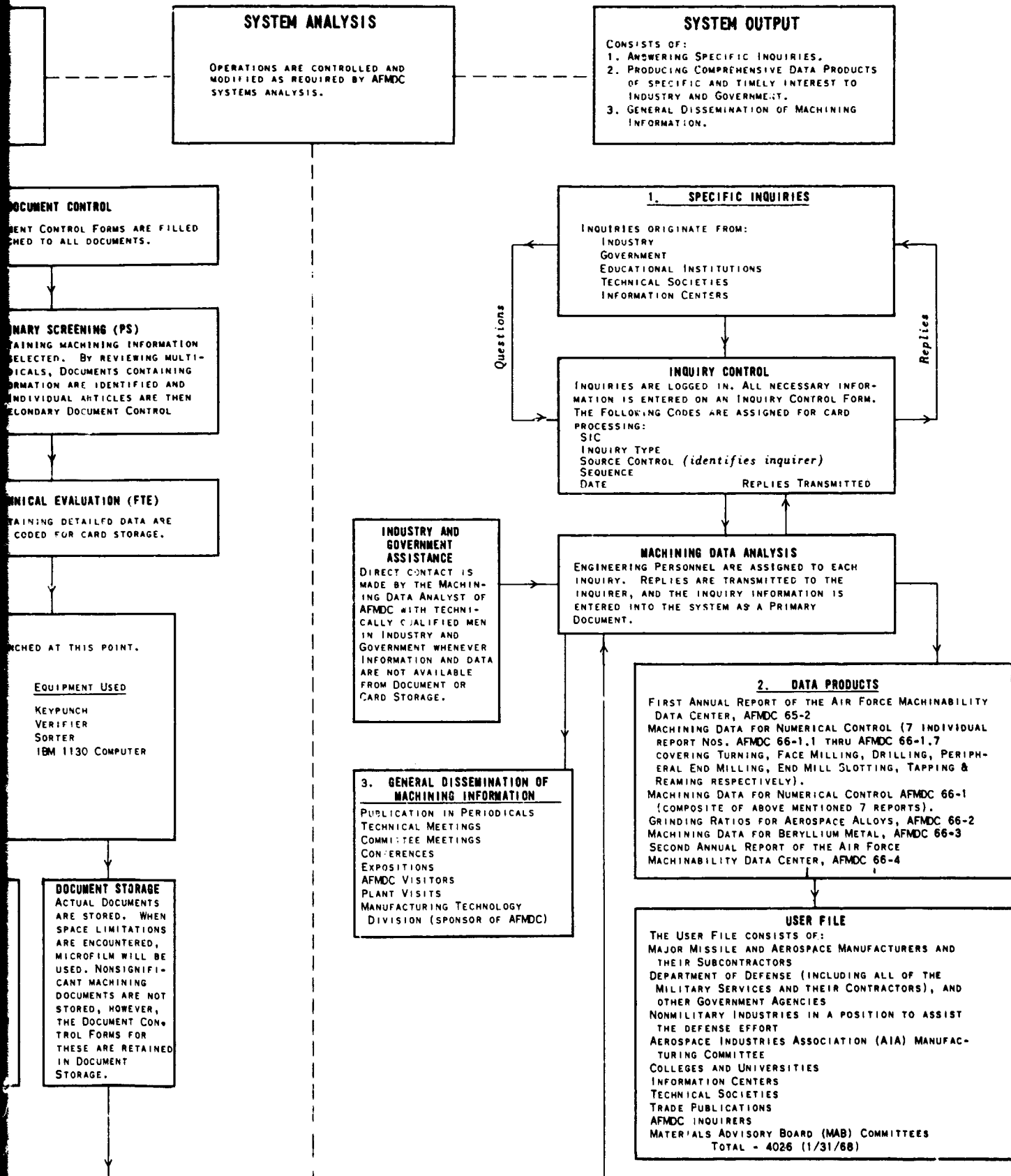
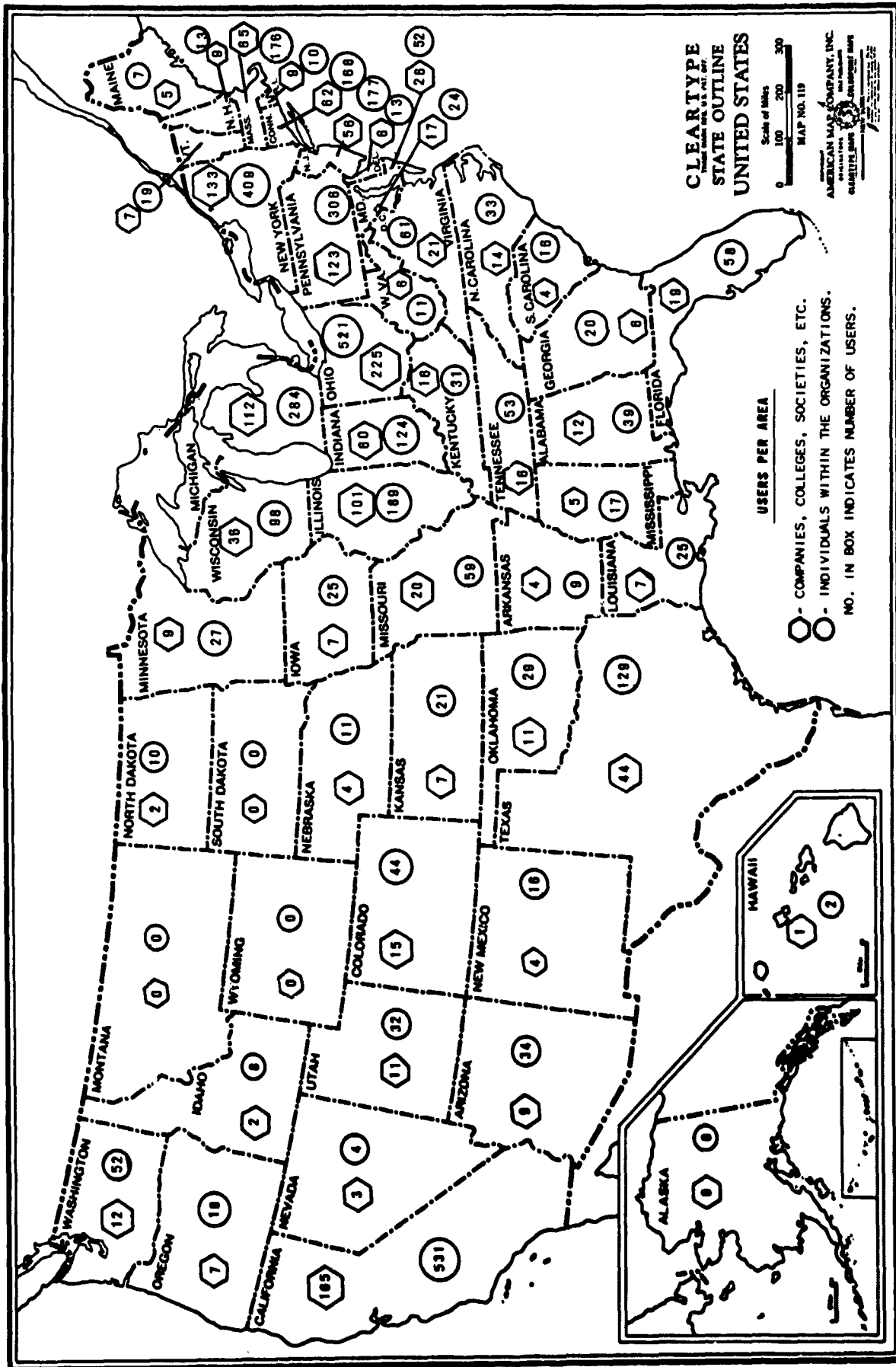


FIGURE 2

# AFMDC OPERATIONS CHART



# AFMDC USER FILE MAP



## DISTRIBUTION OF AFMDC USER FILE

The basic User File was developed as indicated in Appendix, Page A-4. Names are added to the User File as a result of 1) inquirers, 2) visitors, 3) additional names submitted by current Users, 4) requests resulting from dissemination of data products, and 5) technical articles published in periodicals and announcements pertaining to the Center.

### GENERAL CONCENTRATION OF USERS BY NUMBERS

STATES	ORGANIZATIONS	TOTAL NO. ORGANIZATIONS	STATES*	INDIVIDUAL	TOTAL INDIVIDUAL USERS
4	0	0	4	0	0
21	1-10	117	21	1-25	310
13	11-25	201	8	26-50	269
3	26-50	108	8	51-125	557
4	51-100	243	8	126-300	1,123
6	OVER-100	859	4	OVER-300	1,787

### AREA CONCENTRATION OF ORGANIZATIONS

West Coast (3 states) -	184 companies
North Midwest (5 states) -	534 companies
Northeast (5 states) -	430 companies

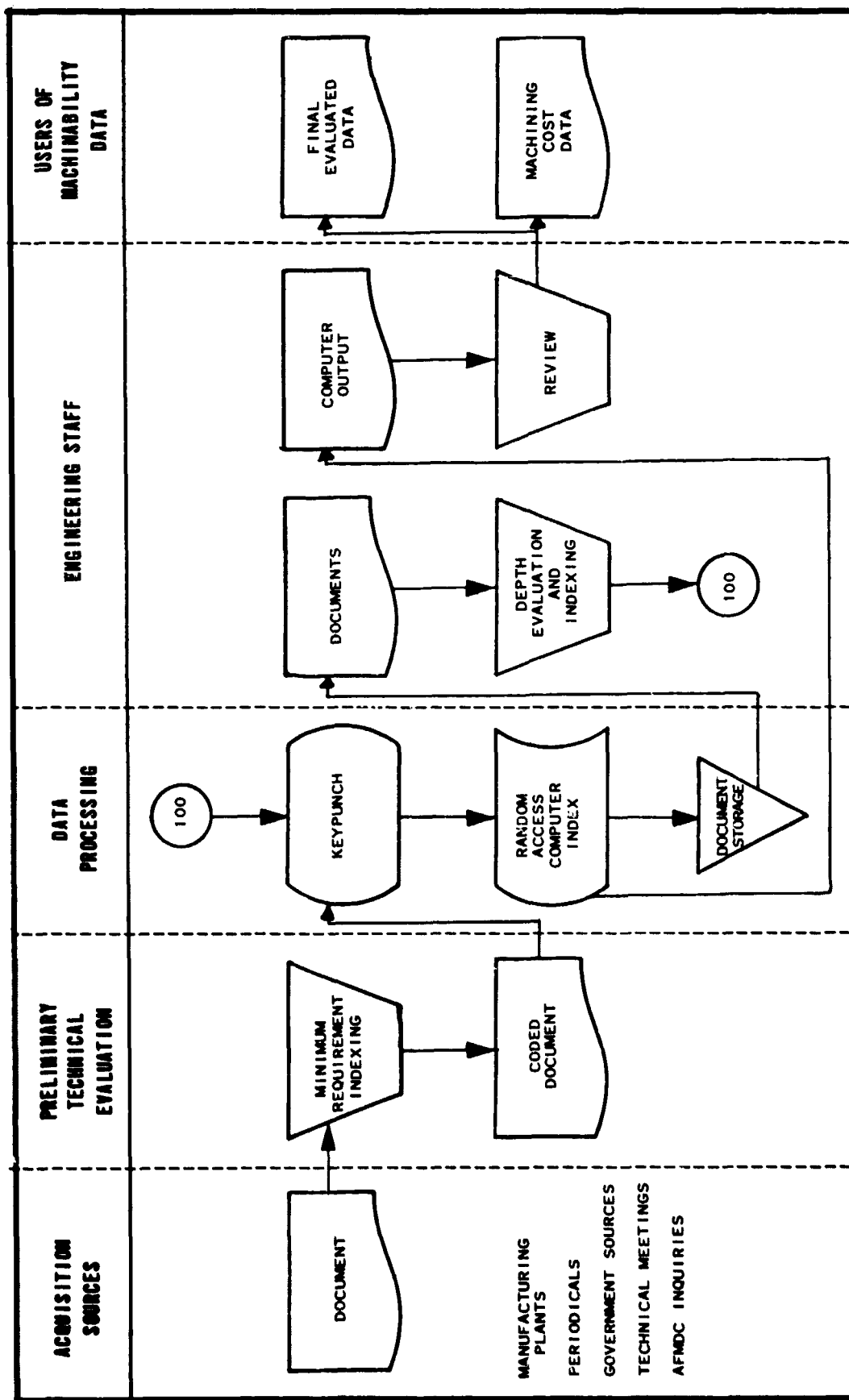
These figures indicate that 75% of User companies lie in 25% of the United States.

The total User File (4,026), can be broken down as follows:

Company Users (Individuals)	3,122
Companies	1,238
College Users (Individuals)	734
Colleges	185
Societies, Centers, etc. (Individuals)	170
Societies, Centers, etc.	103

\*Includes Washington, D.C.

# COMPUTER INPUT AND OUTPUT FLOW CHART



### DATA CODE FORMS FOR FINAL TECHNICAL EVALUATION

[illegible]

**SIDE 1**

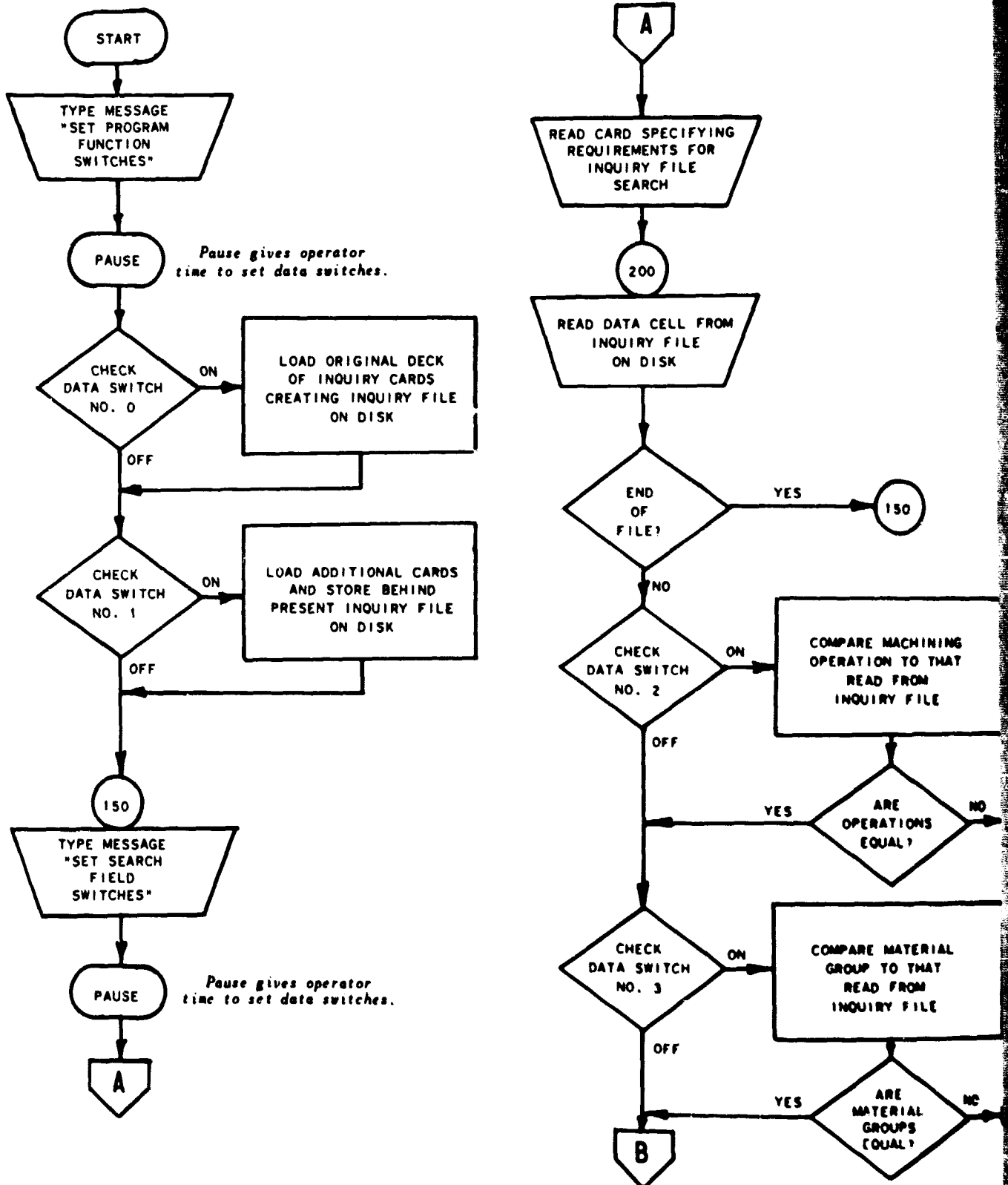
[illegible]

**210E 2**

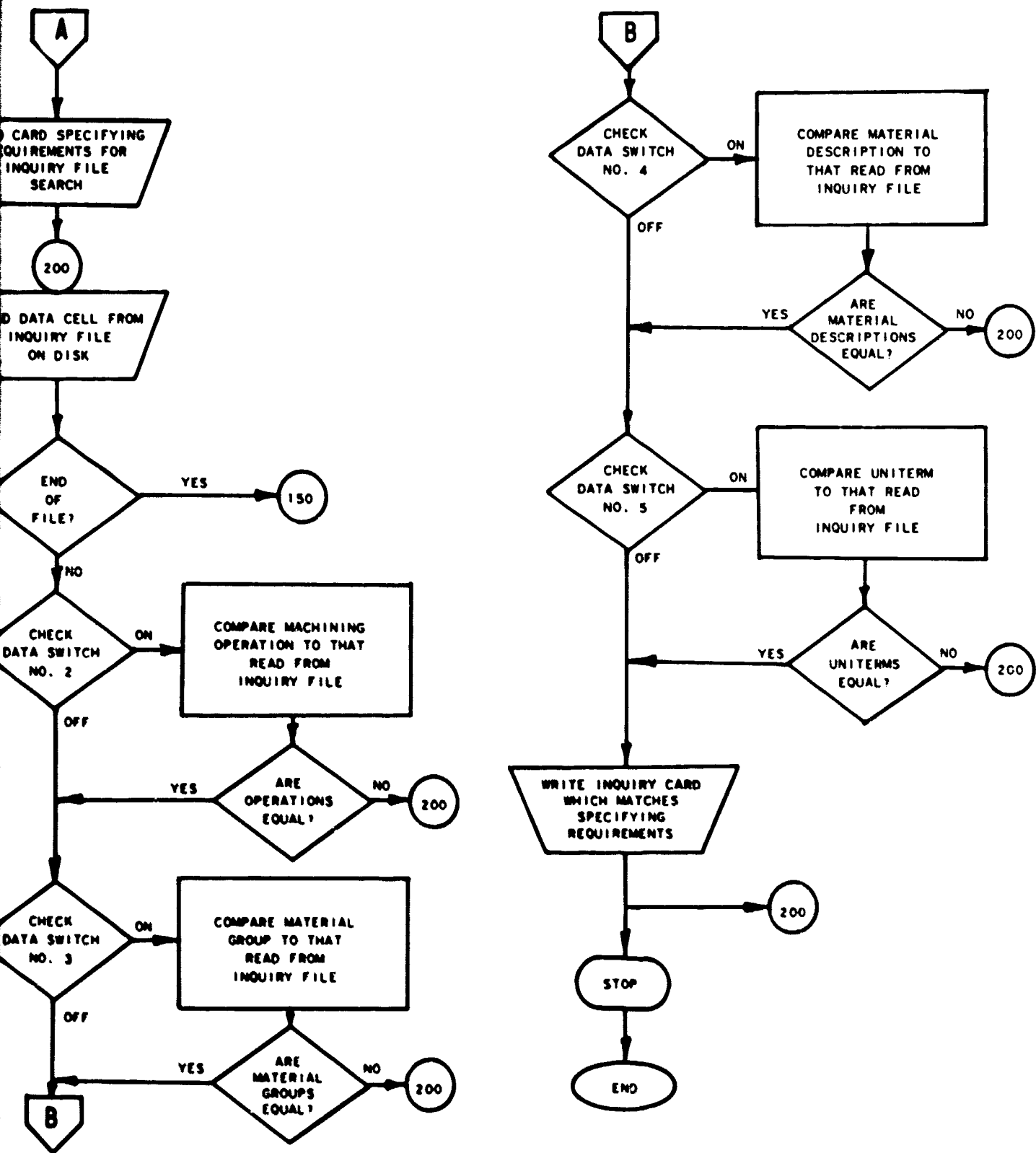
**FIGURE 5**



# **FLOW CHART FOR FORTRAN PROGRAM TO STORE,**



AT FOR FORTRAN PROGRAM TO STORE, ADD OR SEARCH INQUIRY FILE



# INQUIRY FILE SEARCH

CONTROL ON DATA SWITCH NO. 5 - UNITERM, CUT FLUID

OPER	MG	MAT DESCRP	UNITERMS	SIC	CO	SEQ	DATE
0	0		0 CUT FLUID				
170	301	INCOX750	1 CUT FLUID	3541	41 11	63	2015
0	0		14 CARB TOOLSCUT FLUID	3610	42 11	97	3035
0	301	WASPALLOY	2 CUT FLUID TOOL GEOM	3722	79 11	112	3045
0	0		14 CUT FLUID STRESS -CORROSION	2911	82 11	119	3125
1	301	INCOX750	13 CUT FLUID	3722	35 11	138	3185
85	301	INCOX750	13 CUT FLUID	3722	35 1	138	3185
55	301	INCOX750	13 CUT FLUID	3722	35 1	138	3185
1	301	INCO722	13 CUT FLUID	3722	35 1	138	3185

SET SEARCH FIELD SWITCHES

CONTROL ON DATA SWITCHES NOS. 3, 4 & 5 - MATL GRP, 301: MATL DESCRIP, INCO X750; UNITERM, CUT FLUID

OPER	MG	MAT DESCRP	UNITERMS	SIC	CO	SEQ	DATE
0	301	INCOX750	0 CUT FLUID				
170	301	INCOX750	1 CUT FLUID	3541	41 11	63	2015
1	301	INCOX750	13 CUT FLUID	3722	35 11	138	3185
85	301	INCOX750	13 CUT FLUID	3722	35 1	138	3185
55	301	INCOX750	13 CUT FLUID	3722	35 1	138	3185

SET SEARCH FIELD SWITCHES

CONTROL ON DATA SWITCHES NOS. 2, 3, 4 & 5 - OPERATION, 005 (DRILLING); MATL GRP, 301: MATL DESCRIP, INCO X750; UNITERM, CUT FLUID

OPER	MG	MAT DESCRP	UNITERMS	SIC	CO	SEQ	DATE
85	301	INCOX750	0 CUT FLUID				
85	301	INCOX750	13 CUT FLUID	3722	35 1	138	3185

# OUTPUT OF PRELIMINARY TECHNICAL EVALUATED DATA

OPER	MON	MC	MT	MTG	MAT DESCRIP	TM	SOURCE CONTROL CODE
085				301			
085	C48	01	61	301	INCO718	C	229012 0640001401011
085	C35	01	00	301	RENE41	MS	50200280640001243451
085	C34	01	00	301	INCOX750	MS	7320025863128228371
085	C51	03	61	301	UD500	C	807011 4640001401011
085	C40	01	61	301	UD700	MS	8110021060200127981
085	C35	03	60	301	RENE41	MS	8110021060200127981
085	C25	03	00	301	WASPALOY	MS	81100678620001262741
085	C39	03	61	301	RENE41	MS	817004 4650001401011
085	C34	01	60	301	INCO8001	C	817012 6670001092571
085	C41	03	61	301	RENE41	MS	817012 6670001092571
085	C37	03	60	301	INCOX750	MS	817012 6670001092571
085	C41	00	61	301	RENE41	MS	91100148611101234351
085	C35	01	67	301	INCOX750	C	917000 4590001401021
085	C33	01	00	301	INCOX750	MS	92200448641001277781
085	C27	03	00	301	INCOX750	MS	92200448641001275761
085	B89	03	00	301	HASTX	MS	92200448641001253541
085	C35	00	00	301	HASTX	MS	92200448641001249501
085	C36	01	04	301	INCO100C	C	950010C8660005267721
085	C39	01	61	301	RENE41	MS	950010E8660005249591

SEE APPENDIX, PAGE A-0

# OUTPUT OF UNITERM FILE SEARCH

TOOL GEOM 301  
085

FIGURE 8

TOOL GEOM TRBL SHOOTMACHG -TECHNIQUES 487000 6660001 01 4  
110 004 085 040 125 301 487000 660001

TOOL STDS MACH TOOL-AUTOMATIC NC TOOL GEOM TOOL DESGN500000 8580001 01 4  
001 085 055 155 020 030 100 301 051 500000 580001

TOOL GEOM 301  
085 505000 6640006 01 4  
505000 640006

TOOL GEOM CUT FLUID FEED RATE 301  
020 085 100 506000 6630006 01 4  
506000 630006

TOOL GEOM DRL GRNDG DEEP HOLE TOOL HLDR 301  
085 020 100 040 045 050 512000 6510007 01 4  
512000 610007

TOOL GEOM MACHG -TECHNIQUESTOOL DESGNTAP SPECS 605000 6590001 01 4  
085 110 300 281 076 301 605000 590001

TOOL GEOM -TORQUE THRUST TOOL FAILR 301  
085 605003 6640001 01 4  
605003 640001

TOOL GEOM STD SPEC FOREIGN 301  
001 085 624002 6550001 01 4  
624002 550001

MACHG DATATOOL GEOM MACHG -TECHNIQUES 677000 6600001 01 4  
085 301 677000 600001

TOOL GEOM DRILL -THEORY CUT FLUID-EFFECT 301  
085 734007 6660001 01 4  
734007 660001

DRL GRNDG CUTTER -GRNDG -SPECS TOOL GRNDGTOOL GEOM 803004 8510013 01 4  
085 055 225 301 803004 510013

TOOL GEOM TORQUE THRUST SPIRAL PT 301  
085 810001 8570001 01 4  
810001 570001

SHEAR -ANGLE TOOL GEOM CUT FORCE 301  
001 056 085 810006 6510001 01 4  
810006 510001

MCHNBLY -RATING TOOL GEOM TOOL LIFE CUT FLUID 301  
001 085 056 073 070 110 100 811000 8620001 01 4  
811000 620001

DRL GRNDG CUTTER -GRNDG -SPECS TOOL GRNDGTOOL GEOM 803004 8510013 01 4  
085 055 225 301 803004 510013

12

SEE APPENDIX, PAGE A-9

SEE APPENDIX, PAGE A-9

* MACHINING *	MATERIAL	* HEAT TREAT *	MATERIAL *	A F M D C	DATA	INDEX *
* OPERATION *	GROUP	DESCRIPTION	CONDITION *	HARDNESS *	SOURCE	STATUS * CLASS *
TURN, SINGLE PNT	301	INCO718	SOLUTIONED	ROCK C29		
TURN, SINGLE PNT	301	INCO718	SOLUTIONED	ROCK C29	950002 660019	EB

AEMDC

*****											
*TOOL GEOMETRY *											
***** (SEE CHART) *											
TOOL STYLE	* BACK RAKE	* SIDE RAKE	* END SELF	* ECEA DEG	* SCEA DEG	* NOSE RADIUS	* CHIP TYPE	* BREAKER WIDTH	* INCH INCH		
11 161	00	0 05	05	15	15	0.032	*****	*****	*****	AEMDC	

CUTTING FLUID	CUTTING FLUID	CUTTING FLUID	CONCENTRATION
DESCRIPTION	TRADE NAME	DESCRIPTION	
***** TUDI *			
*TOOL MATL-FLUID*			
*****MATERIAL*			
C2 K68	NOT REPORTED	WATER SOLUBLE OIL -LIGHT DUTY	1 TO 020 AFMDC

*NUMERICAL DATA*	CUT	* FEED *	* DEPTH *	* TOOL *	* WEAR *	* SURF *	* UNIT *
* FT/MIN *	* IN/REV *	* INCH *	* MIN *	* LIFE *	* LAND *	* FIN *	* H P *
						RMS	HP/CUIN*
125.	0.009	0.060	10.	0.015	*****	*****	*****
							AEMDC
110.	0.009	0.060	15.	0.015	*****	*****	*****
							AEMDC
98.	0.009	0.060	30.	0.015	*****	*****	*****
							AEMDC
90.	0.009	0.060	45.	0.015	*****	*****	*****
							AEMDC

# COST PER PIECE IN FACE MILLING AND END MILLING

## INSERTED TOOTH CUTTER - CARBIDE TIP OR HSS BLADE

$$C = M \left[ \frac{D(e+L)}{3.82 Z t_v} + \frac{2a+e+L}{x} + t_l + \frac{t_o}{N_l} + \frac{L t_c}{Z T_t} \right] + \frac{L}{Z T_t} \left[ \frac{C_p}{(k_1+1)} + G t_s + \frac{G t_b}{k_2} + \frac{Z C_c}{k_3} + C_w \right] \quad (14)$$

S/MIN FEEDING TIME  
RAPID TRAVERSE TIME  
LOAD & UNLOAD TIME  
SETUP TIME  
CUTTER CHANGE TIME  
CUTTER BODY DEPRECIATION COST  
CUTTER RESHARPEN COST  
BLADE RESET COST  
BLADE COST  
GRINDING WHEEL COST

## THROWAWAY INSERT CUTTER

$$C = M \left[ \frac{D(e+L)}{3.82 Z t_v} + \frac{2a+e+L}{x} + t_l + \frac{t_o}{N_l} + \frac{L t_c}{Z T_t} \right] + \frac{L}{Z T_t} \left[ \frac{C_p}{(k_1+1)} + \frac{Z C_c}{k_3} \right] \quad (15)$$

S/MIN FEEDING TIME  
RAPID TRAVERSE TIME  
LOAD & UNLOAD TIME  
SETUP TIME  
THROWAWAY INSERT TOTAL INDEX TIME  
CUTTER BODY DEPRECIATION COST  
THROWAWAY INSERT COST

## SOLID HSS CUTTER

$$C = M \left[ \frac{D(e+L)}{3.82 Z t_v} + \frac{2a+e+L}{x} + t_l + \frac{t_o}{N_l} + \frac{L t_c}{Z T_t} \right] + \frac{L}{Z T_t} \left[ \frac{C_p}{(k_1+1)} + G t_s + \frac{G t_b}{k_2} + C_w \right] \quad (16)$$

S/MIN FEEDING TIME  
RAPID TRAVERSE TIME  
LOAD & UNLOAD TIME  
SETUP TIME  
CUTTER CHANGE TIME  
CUTTER DEPRECIATION COST  
CUTTER RESHARPEN COST  
GRINDING WHEEL COST

## SOLID BODY - BRAZED CARBIDE TIP CUTTER

$$C = M \left[ \frac{D(e+L)}{3.82 Z t_v} + \frac{2a+e+L}{x} + t_l + \frac{t_o}{N_l} + \frac{L t_c}{Z T_t} \right] + \frac{L}{Z T_t} \left[ \frac{C_p}{(k_1+1)} + G t_s + \frac{G t_b}{k_2} + \frac{Z C_c}{k_3} + C_w \right] \quad (17)$$

S/MIN FEEDING TIME  
RAPID TRAVERSE TIME  
LOAD & UNLOAD TIME  
SETUP TIME  
CUTTER CHANGE TIME  
CUTTER BODY DEPRECIATION COST  
CUTTER RESHARPEN COST  
CARBIDE REBRAZE COST  
CARBIDE TIP COST  
GRINDING WHEEL COST

# COST AND PRODUCTION RATE FOR MILLING

## INSERTED TOOTH - CARBIDE TIP OR HSS BLADE

DATA SET NO.	WORK MATERIAL	HARDNESS	TOOL	CUT	FEED/TOOL	SPD	TOOTH LIFE	F/M	IN	IN/TH	FEED	RAPD	LOAD	SET	UP	CHNG	DEPR	SHPN	RSET	CUTR	BODY	CUTR	BLAD	BLAD	GRND	TOTAL	PROD	COST	RATE	\$/PC	PC/HR
101	WASPALLOY	302	C-2	142	0.005	12.0		0.47	0.03	0.44	0.08	0.16	0.01	1.33	0.12	0.19	0.03									2.86	7.3				
102	WASPALLOY	302	C-2	92	0.005	24.0		0.73	0.03	0.44	0.08	0.08	0.01	0.66	0.06	0.09	0.01									2.19	6.4				
103	WASPALLOY	302	C-2	74	0.005	17.0		0.91	0.03	0.44	0.08	0.11	0.01	0.94	0.08	0.13	0.02									2.75	5.5				

SEE APPENDIX, PAGE A-10

## THROWAWAY INSERT

DATA SET NO.	WORK MATERIAL	HARDNESS	TOOL MAYL	CUT	FEED/TOOL	SPD	TOOTH LIFE	F/M	IN	IN/TH	FEED	RAPD	LOAD	SET UP	CHNG	DEPR	SHPN	RSET	CUTR	BODY	CUTR	BLAD	BLAD	GRND	TOTAL	PROD	COST	RATE	\$/PC	PC/HR
201	WASPALLOY	302	C-2	142	0.005	12.0	0.47	0.03	0.44	0.08	0.09	0.03	0.20	1.34	7.8															
202	WASPALLOY	302	C-2	92	0.005	24.0	0.73	0.03	0.44	0.08	0.04	0.03	0.10	1.45	6.6															
203	WASPALLOY	302	C-2	74	0.005	17.0	0.91	0.03	0.44	0.08	0.07	0.03	0.14	1.70	5.7															

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## SOLID HIGH SPEED STEEL CUTTER

DATA SET NO.	WORK MATERIAL	HARDNESS	TOOL	CUT	FEED/TOOL	SPD	TOOTH LIFE	F/M	IN	IN/TH	FEED	RAPD	LOAD	SET UP	CHNG	DEPR	SHPN	RSET	CUTR	BODY	CUTR	BLAD	BLAD	GRND	TOTAL	PROD	COST	RATE	\$/PC	PC/HR
301	WASPALLOY	302	M-2	32	0.011	20.0	0.41	0.03	0.44	0.08	0.04	0.07	0.34	0.04	1.45	8.7														
302	WASPALLOY	302	M-2	29	0.011	60.0	0.43	0.03	0.44	0.08	0.01	0.02	0.11	0.02	1.16	8.6														
303	WASPALLOY	302	M-2	25	0.011	135.0	0.53	0.03	0.44	0.08	0.00	0.01	0.06	0.01	1.16	8.1														

FIGURE 12



## PRINTOUT FOR INVESTIGATING RELATIONSHIPS BETWEEN MACHINING VARIABLES

**FIGURE 3**

~~AUTOMATIC COMPARE - OPERATION 001 (TURNING) ON FILE~~  
~~REQUESTED VARIABLY - HANDREX~~

СЛУЖБА ЗАШТИТЕ ПРАВА ЧОВЕКА

COMPARE OPERATION 001 FEEDS WITH OPERATION 002 FEEDS

[illegible]

NUM=1003 \* 011-0836 \* 71W \*\*\*\*\*  
 DD=1728 \* SMT INTERV \* TOTL \*\*\*\*\*  
 WFLIGHT ENG \*\*\*\*\*

**ESTIMACIÓN - MARZO - 1974**

0570 766 0570 0510  
R 057 0570 0510  
0570 766 0570 0510

08707  
08706  
08705  
08704  
08703  
08702  
08701

[illegible]

**PET**

VARIABLE - HARDNESS

[illegible]

**ASTA: 000 0000**

832007H - 770V1877

Year	1950	1951	1952	1953	1954	1955	1956	1957	1958	1959	1960	1961	1962	1963	1964	1965	1966	1967	1968	1969	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039	2040	2041	2042	2043	2044	2045	2046	2047	2048	2049	2050	2051	2052	2053	2054	2055	2056	2057	2058	2059	2060	2061	2062	2063	2064	2065	2066	2067	2068	2069	2070	2071	2072	2073	2074	2075	2076	2077	2078	2079	2080	2081	2082	2083	2084	2085	2086	2087	2088	2089	2090	2091	2092	2093	2094	2095	2096	2097	2098	2099	2100																																																																																																								
1950	1.51	1.53	1.55	1.57	1.59	1.61	1.63	1.65	1.67	1.69	1.71	1.73	1.75	1.77	1.79	1.81	1.83	1.85	1.87	1.89	1.91	1.93	1.95	1.97	1.99	2.01	2.03	2.05	2.07	2.09	2.11	2.13	2.15	2.17	2.19	2.21	2.23	2.25	2.27	2.29	2.31	2.33	2.35	2.37	2.39	2.41	2.43	2.45	2.47	2.49	2.51	2.53	2.55	2.57	2.59	2.61	2.63	2.65	2.67	2.69	2.71	2.73	2.75	2.77	2.79	2.81	2.83	2.85	2.87	2.89	2.91	2.93	2.95	2.97	2.99	3.01	3.03	3.05	3.07	3.09	3.11	3.13	3.15	3.17	3.19	3.21	3.23	3.25	3.27	3.29	3.31	3.33	3.35	3.37	3.39	3.41	3.43	3.45	3.47	3.49	3.51	3.53	3.55	3.57	3.59	3.61	3.63	3.65	3.67	3.69	3.71	3.73	3.75	3.77	3.79	3.81	3.83	3.85	3.87	3.89	3.91	3.93	3.95	3.97	3.99	4.01	4.03	4.05	4.07	4.09	4.11	4.13	4.15	4.17	4.19	4.21	4.23	4.25	4.27	4.29	4.31	4.33	4.35	4.37	4.39	4.41	4.43	4.45	4.47	4.49	4.51	4.53	4.55	4.57	4.59	4.61	4.63	4.65	4.67	4.69	4.71	4.73	4.75	4.77	4.79	4.81	4.83	4.85	4.87	4.89	4.91	4.93	4.95	4.97	4.99	5.01	5.03	5.05	5.07	5.09	5.11	5.13	5.15	5.17	5.19	5.21	5.23	5.25	5.27	5.29	5.31	5.33	5.35	5.37	5.39	5.41	5.43	5.45	5.47	5.49	5.51	5.53	5.55	5.57	5.59	5.61	5.63	5.65	5.67	5.69	5.71	5.73	5.75	5.77	5.79	5.81	5.83	5.85	5.87	5.89	5.91	5.93	5.95	5.97	5.99	6.01	6.03	6.05	6.07	6.09	6.11	6.13	6.15	6.17	6.19	6.21	6.23	6.25	6.27	6.29	6.31	6.33	6.35	6.37	6.39	6.41	6.43	6.45	6.47	6.49	6.51	6.53	6.55	6.57	6

**APPENDIX 4**

010 22 0510 H 055 0570 T T  
RECEIVED 12 JAN 1955

DATE	DESCRIPTION	AMOUNT	BALANCE
1950	1000	1000	1000
1951	1000	1000	2000
1952	1000	1000	3000
1953	1000	1000	4000
1954	1000	1000	5000
1955	1000	1000	6000
1956	1000	1000	7000
1957	1000	1000	8000
1958	1000	1000	9000
1959	1000	1000	10000
1960	1000	1000	11000
1961	1000	1000	12000
1962	1000	1000	13000
1963	1000	1000	14000
1964	1000	1000	15000
1965	1000	1000	16000
1966	1000	1000	17000
1967	1000	1000	18000
1968	1000	1000	19000
1969	1000	1000	20000
1970	1000	1000	21000
1971	1000	1000	22000
1972	1000	1000	23000
1973	1000	1000	24000
1974	1000	1000	25000
1975	1000	1000	26000
1976	1000	1000	27000
1977	1000	1000	28000
1978	1000	1000	29000
1979	1000	1000	30000
1980	1000	1000	31000
1981	1000	1000	32000
1982	1000	1000	33000
1983	1000	1000	34000
1984	1000	1000	35000
1985	1000	1000	36000
1986	1000	1000	37000
1987	1000	1000	38000
1988	1000	1000	39000
1989	1000	1000	40000
1990	1000	1000	41000
1991	1000	1000	42000
1992	1000	1000	43000
1993	1000	1000	44000
1994	1000	1000	45000
1995	1000	1000	46000
1996	1000	1000	47000
1997	1000	1000	48000
1998	1000	1000	49000
1999	1000	1000	50000
2000	1000	1000	51000
2001	1000	1000	52000
2002	1000	1000	53000
2003	1000	1000	54000
2004	1000	1000	55000
2005	1000	1000	56000
2006	1000	1000	57000
2007	1000	1000	58000
2008	1000	1000	59000
2009	1000	1000	60000
2010	1000	1000	61000
2011	1000	1000	62000
2012	1000	1000	63000
2013	1000	1000	64000
2014	1000	1000	65000
2015	1000	1000	66000
2016	1000	1000	67000
2017	1000	1000	68000
2018	1000	1000	69000
2019	1000	1000	70000
2020	1000	1000	71000
2021	1000	1000	72000
2022	1000	1000	73000
2023	1000	1000	74000
2024	1000	1000	75000
2025	1000	1000	76000
2026	1000	1000	77000
2027	1000	1000	78000
2028	1000	1000	79000
2029	1000	1000	80000
2030	1000	1000	81000
2031	1000	1000	82000
2032	1000	1000	83000
2033	1000	1000	84000
2034	1000</		

02-21

**EXPLANATION OF VARIABLES** - **EXPLANATION OF VARIABLES**  
**EXPLANATION OF VARIABLES** - **EXPLANATION OF VARIABLES**

0100 110 0510 10 000 0000 111 1

1	31 690
18	72 07
19	03 15 0
20	196 196
21	0010 : 0010

[illegible]

**RESEARCH - MARKET**

3300

**RECEIVED**

**ARIABLE - HARDNESS**

[illegible][illegible]

1

# COMPUTER PRINTOUT OF A SELECTIVE SEARCH ON SURFACE INTEGRITY BIBLIOGRAPHY FILE

NO. OF RECORDS ON FILE BEFORE EXECUTION IS 666.

MATERIAL SEARCH.

OPERATION SEARCH.

PROPERTIES SEARCH.

AUTHOR	MATERIAL	OPERATION	PROPERTIES	SOURCE NO.
ALEKSANDROV, V.P.	FC	IV	ABC	67901
ARTAMONOVA, A. YA.	BFG	IR	C	67767
CHURAROV, A.D.	F	ALA	AC	101150
CLONITZ, P.A.	F	I	ABML	122958
DONACHIE, H.A.	GENEL	DIMSKYTU	CE	100968
FIELD, M.	GABCFZ	ABLT	LACE	103768
FIELD, M.	GZABCF	ABLT	LACE	103886
FIELD, M.	GZABCF	ABLT	LACE	103907
FIELD, M.	SEA	I	ACL	128382
FIELD, M.	BF	LITAV	ACME	761067
GLIMAN, L.A.	F	I	CF	673067
MALVERNSTADT, R.D.	GF	I	CABE	507955
MEMPEL, M.	F	IMY	AFM	742805
KORENEVSKIY, YE. YA.	F	MI	ANF	677606
LIU, H.W.	F	AKL	FABZ	133456
LIU, H.W.	F	EO	FART	133756
LOGIMOV, V.YE.	FC	AI	C	675062
LOGIMOV, V.YE.	F	I	C	675500
LOGIMOV, V.YE.	F	I	C	679580
MEYER, D.T.	REF	MIPOD	COFF	126067
MITRYAYEV, K.F.	F	ALK	CE	678268
REED, T.C.	F	IM	COFE	119059
ROONEY, R.J.	F	AIMST3	COFE	119757
SIMKOVICH, E.A.	F	SASHIT	BF	127558
SIMCLAIR, G.M.	F	87IEV	AFI	122155
SIEMAN, J.A.	F	I	CF	522258
SIEMAR, D.A.	F	I	C	532858
UNIVERSITY, P.P.	FC	OI	C	678306
URYSKIV, P.P.	BFG	OI	BGE	678006
URON	BF	I	CPE	121565
AND	BF	AIV	ACL	740906

SEARCH COMPLETED.  
RESET SWITCHES AND PUSH START TO BEGIN ANOTHER SEARCH.  
ALL SWITCHES OFF CALLS EXIT ROUTINE.

NO FURTHER SEARCHES REQUESTED. CALL EXIT.

COMPUTER PRINTOUT FOR METAL REMOVAL RATES

METAL REMOVAL RATES FOR TURNING

MATERIAL	CONDITION	BHN	GRADE	SPEED FPM	DIAMETER IN.	WORK IN.	TOOL	RPM	FEED IPR	CUT IN.	DEPTH OF	FEED RATE IN./MIN.	METAL REMOVAL RATE CU.IN./MIN.
T16AL4V	ANN	310	HSS	80.	2.000	152.	0.007	0.025	1.06	0.16			
T16AL4V	ANN	310	HSS	70.	2.000	133.	0.008	0.100	1.06	0.67			
T16AL4V	ANN	310	HSS	60.	2.000	114.	0.010	0.200	1.14	1.44			
T16AL4V	ANN	310	CARBIDE	210.	2.000	401.	0.007	0.025	2.80	0.44			
T16AL4V	ANN	310	CARBIDE	180.	2.000	343.	0.011	0.100	3.78	2.37			
T16AL4V	ANN	310	CARBIDE	150.	2.000	286.	0.015	0.200	4.29	5.39			

FIGURE 15

METAL REMOVAL RATES FOR FACE MILLING

MATERIAL	CONDITION	BHN	GRADE	SPEED FPM	DIA. IN.	MILL IN.	TOOL	RPM	FEED IPR	WIDTH OF	DEPTH OF	FEED RATE IN./MIN.	METAL REMOVAL RATE CU.IN./MIN.
T16AL4V	ANN	310	HSS	90.	6.000	57.	0.002	4.	0.008	4.000	0.050	0.45	0.09
T16AL4V	ANN	310	HSS	65.	6.000	41.	0.004	4.	0.016	4.000	0.100	0.66	0.26
T16AL4V	ANN	310	HSS	40.	6.000	25.	0.006	4.	0.024	4.000	0.200	0.61	0.48

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METAL REMOVAL RATES FOR DRILLING

MATERIAL	CONDITION	BHN	GRADE	SPEED FPM	DIAMETER IN.	DRILL IN.	TOOL	RPM	FEED IPR	PENETRATION RATE IN./MIN.	METAL REMOVAL RATE CU.IN./MIN.
T16AL4V	ANN	310	HSS	30.	0.250	458.	0.005	2.29	0.11		
T16AL4V	ANN	310	HSS	30.	0.500	229.	0.006	1.37	0.27		
T16AL4V	ANN	310	HSS	30.	1.000	114.	0.008	0.91	0.72		

SEE APPENDIX, PAGE A-11

## COST STUDY ANALYSIS OF IBM 1130 COMPUTER

The following statistics are based on

1. Fifteen time studies performed on fifteen inquiries comparing IBM 1130 Computer Processing versus IBM Series 50 Configuration Processing.
2. 500 calculations for production rates and machining costs.

### Inquiry Processing

Average number of inquiries processed per month=	75
Percentage of Inquiries requiring searches=	57%
Inquiries per month for which searches are performed are $57\% \times 75 =$	43
Average cost for processing inquiries with the IBM Series 50 Configuration=	\$70.09
Average cost for processing inquiries with the IBM 1130 Computing System=	\$48.92
Average savings for processing an inquiry using the IBM 1130 Computer=	\$21.17
Inquiry processing savings per month = $43 \times \$21.17 =$	\$910.31
Savings per month in sorting and handling of Index files = $50 \text{ hrs.} \times \$8.16 \text{ per hr.} =$	\$408.00
Savings per month in sorting and handling of Inquiry files = $5 \text{ hrs.} \times \$8.16 \text{ per hr.} =$	\$40.80
Total savings per month=	\$1,359.11
Additional cost per month for IBM 1130 Computer=	\$306.00
Savings per month=	\$1,053.11
Savings per year, $12 \times \$1,053.11 =$	\$12,637.32

### Calculations For Production Rates and Machining Costs

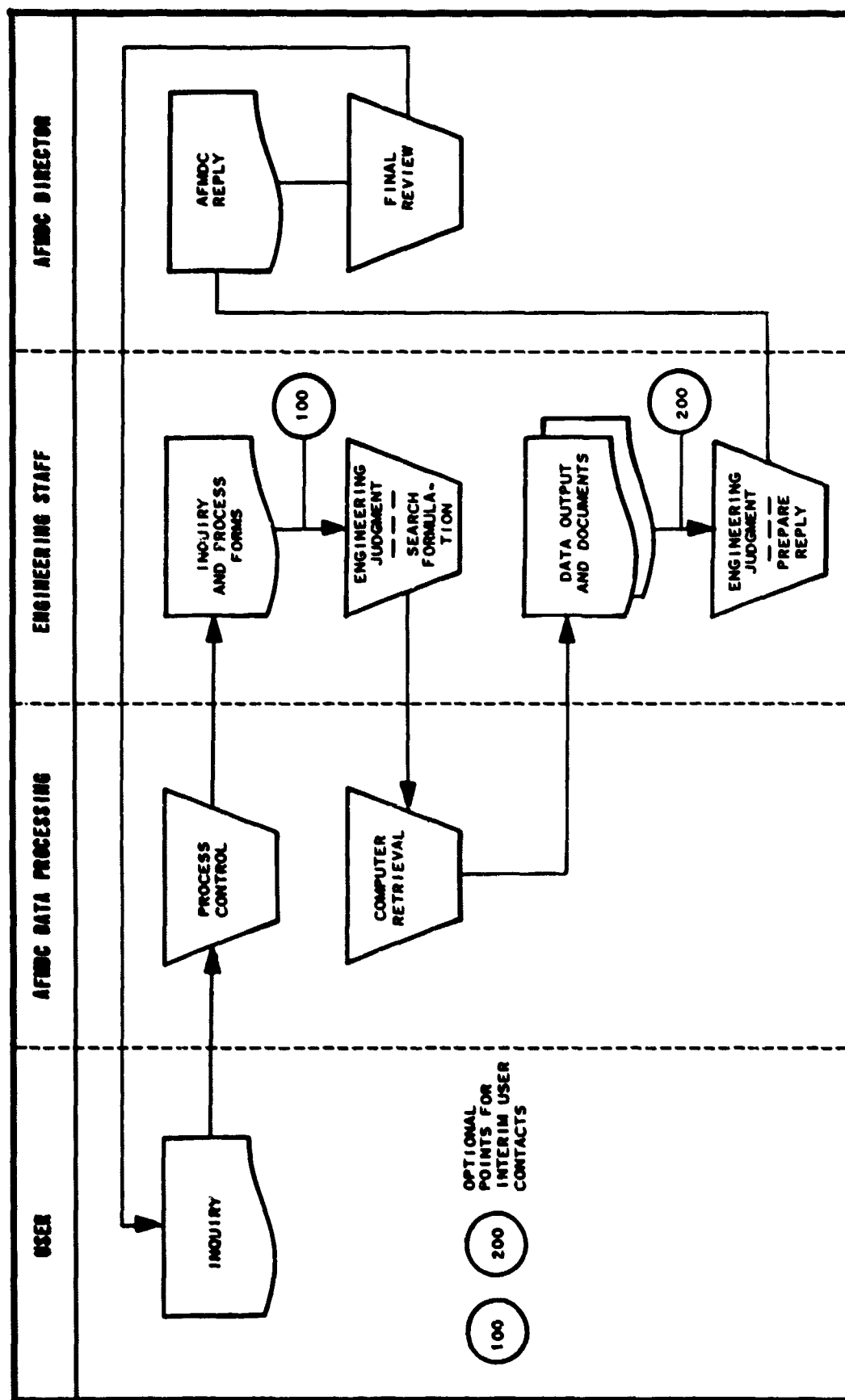
In preparing a data product pertaining to Calculations for Production Rates and Machining Costs, 500 calculations were required:

Time per calculation using desk calculator=	15 min.
Time per calculation using IBM 1130 Computer=	0.3 min.
Savings per calculation=	14.7 min.
Time Savings = $500 \times 14.7 \times 7350 \text{ min.} =$	122.5 hrs.
Cost Savings = $122.5 \times \$8.16 =$	\$999.60

### Summary of Cost Savings:

Inquiry Processing Savings=	\$12,637.32
Calculations Savings=	\$999.60
Savings for one year of operation=	\$13,636.92

**INQUIRY PROCESSING FLOW CHART**



**SEE APPENDIX, PAGE A-11**

NAME (PRINT) \_\_\_\_\_  
 ADDRESS (PRINT) \_\_\_\_\_  
 CITY (PRINT) \_\_\_\_\_  
 STATE (PRINT) \_\_\_\_\_  
 ZIP (PRINT) \_\_\_\_\_  
 PHONE (PRINT) \_\_\_\_\_  
 FAX (PRINT) \_\_\_\_\_  
 E-MAIL (PRINT) \_\_\_\_\_  
 OCCASION (PRINT) \_\_\_\_\_  
 DATE (PRINT) \_\_\_\_\_  
 TIME (PRINT) \_\_\_\_\_  
 SIGNATURE (PRINT) \_\_\_\_\_  
 TITLE (PRINT) \_\_\_\_\_  
 ORGANIZATION (PRINT) \_\_\_\_\_  
 ADDRESS (PRINT) \_\_\_\_\_  
 CITY (PRINT) \_\_\_\_\_  
 STATE (PRINT) \_\_\_\_\_  
 ZIP (PRINT) \_\_\_\_\_  
 PHONE (PRINT) \_\_\_\_\_  
 FAX (PRINT) \_\_\_\_\_  
 E-MAIL (PRINT) \_\_\_\_\_  
 OCCASION (PRINT) \_\_\_\_\_  
 DATE (PRINT) \_\_\_\_\_  
 TIME (PRINT) \_\_\_\_\_  
 SIGNATURE (PRINT) \_\_\_\_\_  
 TITLE (PRINT) \_\_\_\_\_  
 ORGANIZATION (PRINT) \_\_\_\_\_

**AIR FORCE MACHINABILITY DATA CENTER**

JUNE 24, 1967  
 July 24, 1967  
 1967-1968  
 1968-1969

**Mr. E. A. Johnson**  
**Manager, Manufacturing Engineering**  
**Consolidated Manufacturing Corporation**  
**17828 Davidson Road**  
**Wentz, Missouri 64114**

Subject: Request for Face Milling, End Milling and Drilling  
Recommendations for Inco 716 Forgings in the Aged  
Condition at 47 Mg. --  
Contract AF 33(615)-5262

**Thank you for your subject inquiry of July 29, 1967. In response to your request we are pleased to furnish the following information:**

**0302: Building**

Carbide

**Cutting Speed:** 79 feet/minute  
**Feed:** .006 inches/tooth/revolution  
**Tool Material:** C-2  
**Tool Geometry:** AB: 9° ECKA: 5°  
 EB: 7° Cl: 10°  
 CA: 45°  
**Cutting Fluid:** Highly Chlorinated Oil

1

**Cutting Speed:** 25 feet/minute  
**Feed:** .010 inches/teeth/revolution  
**Tooth Material:** T-15  
**Tooth Geometry:** AB: 0° BGEA: 5°  
 BB: 30° CL: 10°  
 CA: 45°  
**Cutting Fluid:** Highly Chlorinated Oil

### Exercises - English part

Cutting Speed:  $1\frac{1}{2}'' \frac{3/4''}{.0015}$   $\frac{1-2''}{.003}$   
 Cutter Diameter:  $\frac{1-2''}{.0015}$   $\frac{1-2''}{.003}$   
 Feed (in./tooth):  $\frac{1-2''}{.0015}$   $\frac{1-2''}{.003}$   
 Tool Material: T-15, M33, M34 or M36

THE FOLLOWING INFORMATION IS FOR THE INFORMATION OF THE OFFICE OF THE ATTORNEY GENERAL AND THE OFFICE OF THE SECRETARY OF THE TREASURY:

**AIR FORCE MAIL**  
...we want to  
...for your future marketing

**ROBERT E. LINDER**  
Robert E. Linder, Supervisor  
Technical Inspection

10/10/2010

# ANALYSIS OF INQUIRIES BY STATE

October 1, 1984 - September 30, 1988

10 STATES LEADING IN INQUIRIES			
STATES	COMPANIES	INDIVIDUALS	NO. OF INQUIRIES
CALIFORNIA	121	227	348
CONNECTICUT	40	62	104
ILLINOIS	84	112	176
INDIANA	50	82	118
MASSACHUSETTS	49	73	126
MICHIGAN	81	120	194
NEW JERSEY	45	93	172
NEW YORK	93	146	244
OHIO	240	448	876
PENNSYLVANIA	90	148	203
TOTAL	893	1511	2581
OTHER STATES SUBMITTING INQUIRIES			
ALABAMA	8	8	11
ARIZONA	9	15	31
ARKANSAS	1	1	1
COLORADO	8	18	31
DISTRICT OF COLUMBIA	9	11	14
DELAWARE	2	17	26
FLORIDA	12	21	60
GEORGIA	4	10	14
IOWA	9	11	15
KANSAS	6	10	12
KENTUCKY	12	20	39
LOUISIANA	3	7	12
MAINE	6	7	10
MARYLAND	20	26	43
MINNESOTA	10	14	17
MISSISSIPPI	2	2	2
MISSOURI	10	30	71
NEBRASKA	1	1	1
NEW HAMPSHIRE	6	6	7
NEW MEXICO	2	11	18
NORTH CAROLINA	5	4	14
OKLAHOMA	3	12	27
OREGON	4	5	9
RHODE ISLAND	7	7	10
SOUTH CAROLINA	2	2	4
TENNESSEE	9	20	49
TEXAS	16	28	59
UTAH	5	6	10
VERMONT	5	6	10
VIRGINIA	16	20	33
WEST VIRGINIA	7	7	13
WASHINGTON	7	25	38
WISCONSIN	19	29	43
TOTAL	245	417	754
TOTAL FOR ALL STATES	1138	1928	3335

# SUMMARY OF SPECIFIC INQUIRIES BY TYPE OF INQUIRY

October 1, 1964 - September 30, 1968

10/1/64  
to  
1/31/68

2/1/68  
to  
1/31/67

2/1/67  
to  
1/31/68

2/1/68  
to  
9/30/68

## NO. OF INQUIRIES

1. RECOMMENDATIONS FOR A SPECIFIC MACHINING SITUATION. <i>Typical Example:</i> Requested recommendations for turning Waspaloy in the solution treated and aged condition.	73	118	180	144
2. STARTING RECOMMENDATIONS FOR AN EXTENSIVE GROUP OF MACHINING SITUATIONS. <i>Typical Example:</i> Requested machinability data on AM-350, S-816, MS-25, MS-31, Inconel X-750, Unitemp M-252 and Hastelloy R-235.	118	264	330	345
3. INFORMATION PERTAINING TO NEW MACHINING PROCESSES, EQUIPMENT AND TOOLS. <i>Typical Example:</i> Requested information on the manufacturer of equipment called "Liquid Lathe."	45	27	78	104
4. COORDINATION AND POTENTIAL USE OF AFMDC. <i>Typical Example:</i> Requested detailed information on services available from AFMDC.	77	29	40	48
5. VISITS TO THE CENTER. <i>Typical Example:</i> Visited to coordinate with AFMDC to determine services available and to review System details.	60	78	58	8
6. *REQUESTS FOR SPECIFIC DOCUMENTS, REPORTS, BOOKS, PAPERS, ETC. <i>Typical Example:</i> Requested a list of reports available for machining of titanium. Also wanted cost of each report.	70*	71*	116*	84*
7. GENERAL INFORMATION SUCH AS SAFETY PRACTICES, NAMES OF FIRMS HAVING CERTAIN MACHINING CAPABILITIES, TOOL MATERIAL PROPERTIES, ETC. <i>Typical Example:</i> Requested the names of people to contact in the fields of metal removal such as EDM, ECM, ECG, EDG, USM, CHM, EDM, LDM, Abrasive Machining and Wet Machining.	48	30	18	22
8. REQUESTS FOR BIBLIOGRAPHIES AND ABSTRACTS. <i>Typical Example:</i> Request for bibliographies with abstracts covering use of ceramic tools and abrasives in machining various materials.	12	4	11	13
9. STATE-OF-THE-ART INFORMATION AND REPORTS. <i>Typical Example:</i> Suggestions for important manufacturing programs for the next five years in the field of material removal. Supply problem, approach and approximate funds.	14	8	20	7
10. SPECIAL INQUIRIES AND REPORTS FOR U.S. AIR FORCE, MANUFACTURING TECHNOLOGY DIVISION. <i>Typical Example:</i> Requested a report on the progress during the last five years in machining of titanium and hard to machine materials - state of the art.	12	4	2	1
11. EVALUATION, TRANSLATION AND REVIEW OF REPORTS, BOOKS, PAPERS. <i>Typical Example:</i> Requested an evaluation of a report published in Electro-Technology, October 1964, concerning adaptive control possibilities.	14	12	9	4
12. REQUEST FOR INFORMATION ON BERYLLIUM. <i>Typical Example:</i> Request for information on machinability data for beryllium using ECM, EDM, and other methods.	11	15	14	10
13. COMPARISON OF ONE PROCESS OR MATERIAL WITH ANOTHER. <i>Typical Example:</i> Requested a comparison of the machining of Inconel W with Inconel X in both solution treated and solution treated and aged conditions, primarily in turning but also drilling and milling if possible.	15	13	14	7
14. INFORMATION PERTAINING TO CUTTING FLUIDS. <i>Typical Example:</i> Requested cutting fluid recommendations for titanium and a wide variety of high temperature alloys and stainless steels.	15	22	18	22
15. INFORMATION ON MACHINABILITY RESEARCH. <i>Typical Example:</i> Requested machining information on the effect of work diameter on tool life, mathematical correlations of the various machining processes and the means of predicting the surface quality in milling.	11	37	77	187
16. INFORMATION PERTAINING TO ESTIMATING COST, SETTING TIME STANDARDS, AND PRODUCTION RATES IN MACHINING. <i>Typical Example:</i> Requested information including formulas that could be used to predict production rates and costs.		6	21	58
	585	738	1002	982

\*This total does not include requests for published data products such as AFMDC reports.



## GENERAL ANALYSIS OF INQUIRIES

FEBRUARY 1, 1966 - SEPTEMBER 30, 1968

TYPE OF INQUIRY	NO. OF INQUIRIES		
	2/1/66-1/31/67	2/1/67-1/31/68	2/1/68-9/30/68
ONE OPERATION ON ONE MATERIAL GROUP	90	160	110
ONE OPERATION ON A VARIETY OF MATERIAL GROUPS	50	63	112
SEVERAL OPERATIONS ON ONE MATERIAL GROUP	215	242	195
SEVERAL OPERATIONS ON SEVERAL MATERIAL GROUPS	124	170	151
UNITERM LINKED WITH AN OPERATION AND/OR GROUP	126	111	178
GENERAL MACHINING CONCEPTS (UNITERM)	131	256	236
<b>TOTAL</b>	<b>736</b>	<b>1,002</b>	<b>982</b>

## ANALYSIS OF INQUIRIES BY MATERIAL GROUP

FEBRUARY 1, 1966 - SEPTEMBER 30, 1968

MATERIAL GROUP	NO. OF INQUIRIES		
	2/1/66-1/31/67	2/1/67-1/31/68	2/1/68-9/30/68
PLAIN CARBON & LOW ALLOY STEELS	177	262	293
ULTRA HIGH STRENGTH & TOOL STEELS	171	204	229
CAST IRON	33	36	124
STAINLESS STEELS	173	278	234
NICKEL ALLOYS	29	19	119
MARAGING STEELS	66	77	146
HIGH TEMPERATURE ALLOYS	254	327	309
TITANIUM ALLOYS	234	222	249
REFRACTORY ALLOYS	130	155	184
BERYLLIUM ALLOYS	46	60	88
ZIRCONIUM ALLOYS	7	22	70
ALUMINUM, MAGNESIUM, ZINC, LEAD & COPPER ALLOYS	80	86	149
PRECIOUS & RARE METALS	3	12	7
POWDER METALS	2	2	5
NONMETALLICS INCLUDING CERAMICS, PLASTICS, GRAPHITE & COMPOSITES	57	131	120
<b>TOTAL</b>	<b>1,482</b>	<b>1,893</b>	<b>2,328</b>

# ANALYSIS OF INQUIRIES BY TYPE OF MACHINING OPERATION

FEBRUARY 1, 1966 - September 30, 1968

OPERATION	NO. OF INQUIRIES		
	2/1/66-1/31/67	2/1/67-1/31/68	2/1/68-9/30/68
<b>CONVENTIONAL CHIP REMOVAL</b>			
TURNING	367	499	403
BORING	48	52	83
MILLING (GENERAL)	10	30	129
FACE MILLING	290	375	346
END MILL SLOTTING	285	371	278
PERIPHERAL END MILLING	145	178	156
SLAB MILLING	6	20	20
THREAD MILLING	7	23	16
ALL OTHER TYPES OF MILLING	15	20	24
DRILLING	332	464	379
GUN DRILLING	7	24	30
REAMING	203	311	263
TAPPING	254	357	250
GEAR CUTTING	3	18	8
BROACHING	28	77	50
ROUTING	4	17	9
BANDSAWING	10	64	41
HACKSAWING	15	21	18
<b>TOTAL</b>	<b>2,029</b>	<b>2,921</b>	<b>2,503</b>
<b>CONVENTIONAL GRINDING</b>			
GENERAL GRINDING	27	33	50
SURFACE GRINDING	171	317	243
CYLINDRICAL GRINDING	89	193	89
INTERNAL GRINDING	15	38	23
CENTERLESS GRINDING	6	19	14
GEAR GRINDING	2	15	10
THREAD GRINDING	8	16	4
ABRASIVE MACHINING	4	17	3
ABRASIVE BELT GRINDING	7	17	3
ABRASIVE CUTOFF	12	21	4
HONING	1	15	1
<b>TOTAL</b>	<b>342</b>	<b>701</b>	<b>444</b>
<b>ALTERNATE MACHINING METHODS</b>			
ELECTRICAL DISCHARGE MACHINING	50	50	62
ELECTROCHEMICAL MACHINING	43	44	68
ELECTROCHEMICAL GRINDING	11	27	30
CHEMICAL MACHINING	26	59	35
PHOTOCHEMICAL MACHINING	1	2	4
ULTRASONIC MACHINING	4	15	11
ELECTRON BEAM MACHINING	5	10	13
LASER MACHINING	3	20	14
ION BEAM MACHINING	1	1	5
ABRASIVE JET MACHINING	0	3	3
ELECTRO-STREAM	0	4	5
<b>TOTAL</b>	<b>144</b>	<b>235</b>	<b>250</b>
<b>MISCELLANEOUS</b>			
BURNISHING	1	8	6
CONTROLLED ENERGY MACHINING	0	1	5
SUB-ZERO MACHINING	3	7	6
HOT MACHINING	1	1	4
POLISHING	2	6	3
THREAD ROLLING	0	3	2
FLAME CUTTING	1	2	2
<b>TOTAL</b>	<b>8</b>	<b>28</b>	<b>28</b>
<b>TOTAL</b>	<b>2,523</b>	<b>3,885</b>	<b>3,225</b>

# ANALYSIS OF UNITERM TYPE INQUIRIES

FEBRUARY 1, 1966 - SEPTEMBER 30, 1968

UNITERM*	NO. OF REQUEST		
	2/1/66-1/31/67	2/1/67-1/31/68	2/1/68-9/30/68
SURFACE INTEGRITY	27	92	64
NUMERICAL CONTROL	57	68	46
CUTTING FLUID	69	61	53
SURFACE FINISH	33	59	42
DISTORTION	27	34	23
CUTTING TOOLS - GENERAL	3	22	17
TOLERANCE	5	16	13
G. RATIO	11	15	13
CERAMIC TOOLS	3	14	12
SUPER HARD HIGH SPEED STEEL	5	11	7
ADAPTIVE CONTROL	1	10	8
RESIDUAL STRESS	8	10	14
TITANIUM CARBIDE	2	8	5
PRECISION MACHINING	1	6	7
TOOL SURFACE TREATMENT	1	5	6
METAL REMOVAL RATES	1	1	19
TIME STANDARDS	2	3	13
TOTAL	256	435	362

\* Partial list - 17 most active unitermis

# AIR FORCE MACHINABILITY DATA CENTER

## SUMMARY OF SPECIFIC INQUIRIES BY SIC\* NUMBER

February 1, 1968 - September 30, 1968

SIC MAJOR GROUP NO.	SIC INDUSTRY NO.		NUMBER OF INQUIRIES		
			BY SIC INDUSTRY NO.	BY SIC MAJOR GROUP NO.	% OF TOTAL
91		<b>FEDERAL GOVERNMENT</b>		56	5.7
	9100	U.S. DEPARTMENT OF DEFENSE	1		
	9100	USAF - WRIGHT FIELD	13		
	9100	USAF - APO, NEW YORK	1		
	9100	USAF - TINKER AIR FORCE BASE	12		
	9100	U.S. ARMY	8		
	9100	U.S. NAVY	9		
	9100	NATIONAL AERONAUTICS & SPACE ADMINISTRATION	4		
	9190	BSDA DEPARTMENT OF COMMERCE	1		
	9190	SMALL BUSINESS ADMINISTRATION	6		
	9190	U.S. PUBLIC HEALTH SERVICE	1		
92		<b>STATE GOVERNMENTS</b>		28	2.9
	9200	STATE OF ILLINOIS	1		
	9200	STATE OF INDIANA	2		
	9200	STATE OF MICHIGAN	20		
19		<b>ORDNANCE AND ACCESSORIES</b>		3	.3
	1929	AMMUNITION EXCEPT FOR SMALL ARMS	1		
	1931	TANKS & TANK COMPONENTS	1		
	1951	SMALL ARMS	1		
22		<b>TEXTILE MILL PRODUCTS</b>		1	.1
	2262	FINISHERS OF BROAD WOVEN FABRICS OF MAN-MADE AND SILK	1		
26		<b>PAPER AND ALLIED PRODUCTS</b>		1	.1
	2654	SANITARY FOOD CONTAINERS	1		
27		<b>PRINTING, PUBLISHING, AND ALLIED INDUSTRIES</b>		13	1.3
	2721	PERIODICALS: PUBLISHING, PUBLISHING, AND PRINTING	13		
28		<b>CHEMICALS AND ALLIED PRODUCTS</b>		15	1.5
	2813	INDUSTRIAL GASES	2		
	2819	INDUSTRIAL INORGANIC CHEMICALS	1		
	2821	PLASTICS MATERIALS, SYNTHETIC RESINS, & NONVULCANIZABLE ELASTOMERS	2		
	2824	SYNTHETIC ORGANIC FIBERS, EXCEPT CELLULOSIC	1		
	2833	MEDICINAL CHEMICALS AND BOTANICAL PRODUCTS	9		
29		<b>PETROLEUM REFINING AND RELATED INDUSTRIES</b>		7	.7
	2911	PETROLEUM REFINING	7		
32		<b>STONE, CLAY, GLASS, AND CONCRETE PRODUCTS</b>		9	.9
	3229	PRESSED AND BLOWN GLASS AND GLASSWARE	3		
	3291	ABRASIVE PRODUCTS	6		

\* Standard Industrial Classification Manual (SIC), Executive Office of the President, Bureau of the Budget, 1967.

# NUMBER OF INQUIRIES

SIC MAJOR GROUP NO.	SIC INDUSTRY NO.		BY SIC INDUSTRY NO.	BY SIC MAJOR GROUP NO.	% OF TOTAL
33		<b>PRIMARY METAL INDUSTRIES</b>		49	5.0
	3312	BLAST FURNACE (UNCLUDING COKE OVENS), STEELS WORKS, & ROLLING MILLS	1		
	3313	ELECTROMETALLURGICAL PRODUCTS	1		
	3321	GRAY IRON FOUNDRIES	2		
	3323	STEEL FOUNDRIES	11		
	3332	PRIMARY SMELTING AND REFINING OF LEAD	4		
	3334	PRIMARY PRODUCTION OF ALUMINUM	5		
	3339	PRIMARY SMELTING & REFINING OF NONFERROUS METALS	13		
	3341	SECONDARY SMELTING & REFINING OF NONFERROUS METALS	5		
	3351	ROLLING, DRAWING, AND EXTRUDING OF COPPER	1		
	3369	NONFERROUS CASTINGS	5		
	3391	IRON AND STEEL FORGINGS	1		
34		<b>FABRICATED METAL PRODUCTS, EXCEPT ORDNANCE, MACHINERY, AND TRANSPORTATION EQUIPMENT</b>		65	6.6
	3411	METAL CANS	1		
	3423	HAND AND TOOLS, EXCEPT MACHINE TOOLS AND HAND SAWS	1		
	3429	HARDWARE	4		
	3443	FABRICATED PLATE WORK (BOILER SHOPS)	35		
	3444	SHEET METAL WORK	2		
	3451	SCREW MACHINE PRODUCTS	8		
	3452	BOLTS, NUTS, SCREWS, RIVETS AND WASHERS	2		
	3461	METAL STAMPINGS	1		
	3471	ELECTROPLATING, PLATING, POLISHING, ANODIZING AND COLORING	2		
	3491	METAL SHIPPING BARRELS, DRUMS, KEGS, AND PAILS	3		
	3494	VALVES & PIPE FITTINGS, EXCEPT PLUMBERS' BRASS GOODS	3		
	3496	COLLAPSIBLE TUBES	1		
	3499	FABRICATED METAL PRODUCTS	2		
35		<b>MACHINERY, EXCEPT ELECTRICAL</b>		210	21.4
	3511	STEAM ENGINES; STEAM, GAS, AND HYDRAULIC TURBINES; AND STEAM, GAS, AND HYDRAULIC TURBINE GENERATOR SET UNITS	13		
	3519	INTERNAL COMBUSTION ENGINES	5		
	3522	FARM MACHINERY AND EQUIPMENT	2		
	3533	OIL FIELD MACHINERY AND EQUIPMENT	2		
	3534	ELEVATORS AND MOVING STAIRWAYS	2		
	3536	HOISTS, INDUSTRIAL CRANES, AND MONORIAL SYSTEMS	1		
	3541	MACHINE TOOLS, METAL CUTTING TYPES	56		
	3542	MACHINE TOOLS, METAL FORMING TYPES	3		
	3544	SPECIAL DIES AND TOOLS, DIE SETS, JIGS AND FIXTURES	8		
	3545	MACHINE TOOL ACCESSORIES AND MEASURING DEVICES	27		
	3548	METALWORKING MACHINERY, EXCEPT MACHINE TOOLS; AND POWER DRIVEN HAND TOOLS	3		
	3551	FOOD PRODUCTS MACHINERY	8		
	3559	SPECIAL INDUSTRY MACHINERY	5		
	3561	PUMPS, AIR GAS COMPRESSORS, AND PUMPING EQUIPMENT	9		
	3562	BALL AND ROLLER BEARINGS	3		
	3564	BLOWERS AND EXHAUST VENTILATION FANS	1		
	3566	MECHANICAL POWER TRANSMISSION EQUIPMENT, EXCEPT BALL AND ROLLER BEARINGS	2		
	3567	INDUSTRIAL PROCESS FURNACES AND OVENS	4		
	3569	GENERAL INDUSTRIAL MACHINERY AND EQUIPMENT	2		
	3572	TYPEWRITERS	2		
	3574	CALCULATING AND ACCOUNTING MACHINES, EXCEPT ELECTRONIC COMPUTING EQUIPMENT	6		

FIGURE 23 (cont.)

# NUMBER OF INQUIRIES

SIC MAJOR GROUP NO.	SIC INDUSTRY NO.		BY SIC INDUSTRY NO.	BY SIC MAJOR GROUP NO.	% OF TOTAL
35		<b>MACHINERY, EXCEPT ELECTRICAL (cont.)</b>			
	3579	OFFICE MACHINES	3		
	3582	COMMERCIAL LAUNDRY, DRY CLEANING, AND PRESSING MACHINES	1		
	3585	AIR CONDITIONING EQUIPMENT AND COMMERCIAL AND INDUSTRIAL REFRIGERATION MACHINERY AND EQUIPMENT	3		
	3591	MISCELLANEOUS MACHINERY, EXCEPT ELECTRICAL	39		
36		<b>ELECTRICAL MACHINERY, EQUIPMENT, AND SUPPLIES</b>		80	8.1
	3611	ELECTRIC MEASURING INSTRUMENTS AND TEST EQUIPMENT	8		
	3613	SWITCHGEAR AND SWITCHBOARD APPARATUS	1		
	3621	MOTORS AND GENERATORS	2		
	3622	INDUSTRIAL CONTROLS	4		
	3624	CARBON AND GRAPHITE PRODUCTS	1		
	3629	ELECTRICAL INDUSTRIAL APPARATUS	3		
	3641	ELECTRIC LAMPS	1		
	3643	CURRENT - CARRYING WIRING DEVICES	1		
	3651	RADIO AND TELEVISION RECEIVING SETS, EXCEPT COMMUNICATION TYPES	2		
	3662	RADIO AND TELEVISION TRANSMITTING, SIGNALING, AND DETECTION EQUIPMENT AND APPARATUS	43		
	3673	TRANSMITTING, INDUSTRIAL, AND SPECIAL PURPOSE ELECTRON TUBES	1		
	3679	ELECTRONIC COMPONENTS AND ACCESSORIES	9		
	3694	ELECTRICAL EQUIPMENT FOR INTERNAL COMBUSTION ENGINES	4		
37		<b>TRANSPORTATION EQUIPMENT</b>		333	33.9
	3711	MOTOR VEHICLES	12		
	3712	PASSENGER CAR BODIES	1		
	3714	MOTOR VEHICLE PARTS AND ACCESSORIES	5		
	3721	AIRCRAFT AND MISSILES	197		
	3722	AIRCRAFT ENGINES & ENGINE PARTS - MISSILE ENGINES	70		
	3729	AIRCRAFT PARTS & AUXILIARY EQUIPMENT - MISSILE PARTS	45		
	3731	SHIP BUILDING AND REPAIRING	1		
	3732	BOAT BUILDING AND REPAIRING	1		
	3741	LOCOMOTIVES AND PARTS	1		
38		<b>PROFESSIONAL, SCIENTIFIC, AND CONTROLLING INSTRUMENTS; PHOTOGRAPHIC AND OPTICAL GOODS; WATCHES AND CLOCKS</b>		11	1.1
	3811	ENGINEERING, LABORATORY, AND SCIENTIFIC AND RESEARCH INSTRUMENTS AND ASSOCIATED EQUIPMENT	6		
	3822	AUTOMATIC TEMPERATURE CONTROLS	1		
	3831	OPTICAL INSTRUMENTS AND LENSES	1		
	3842	ORTHOPEDIC, PROSTHETIC, AND SURGICAL APPLIANCES AND SUPPLIES	2		
	3861	PHOTOGRAPHIC EQUIPMENT AND SUPPLIES	1		
50		<b>WHOLESALE TRADE</b>		2	.2
	5082	CONSTRUCTION AND MINING MACHINERY AND EQUIPMENT	1		
	5091	METALS AND MINERALS	1		
60		<b>BANKING</b>		1	.1
	6025	NATIONAL BANKS, MEMBERS OF THE FEDERAL RESERVE SYSTEM	1		

NUMBER OF INQUIRIES

<u>SIC MAJOR GROUP NO.</u>	<u>SIC INDUSTRY NO.</u>		<u>BY SIC INDUSTRY NO.</u>	<u>BY SIC MAJOR GROUP NO.</u>	<u>% OF TOTAL</u>
73		<b>MISCELLANEOUS BUSINESS SERVICES</b>		34	3.5
	7311	ADVERTISING AGENCIES	1		
	7391	COMMERCIAL RESEARCH AND DEVELOPMENT LABORATORIES	29		
	7392	BUSINESS, MANAGEMENT, ADMINISTRATIVE AND CONSULTING SERVICES	4		
82		<b>EDUCATIONAL SERVICES</b>		42	4.3
	8211	ELEMENTARY AND SECONDARY SCHOOLS	8		
	8221	COLLEGES, UNIVERSITIES, AND PROFESSIONAL SCHOOLS	5		
	8231	LIBRARY AND INFORMATION CENTERS	29		
86		<b>NONPROFIT MEMBERSHIP ORGANIZATIONS</b>		5	.5
	8611	BUSINESS ASSOCIATIONS	1		
	8621	PROFESSIONAL MEMBERSHIP ORGANIZATIONS	4		
89		<b>MISCELLANEOUS SERVICES</b>		17	1.8
	8911	ENGINEERING AND ARCHITECTURAL SERVICES	12		
	8921	NONPROFIT EDUCATIONAL AND SCIENTIFIC RESEARCH AGENCIES	5		
<b>TOTALS</b>				<b>982</b>	<b>100.0%</b>

# AIR FORCE MACHINABILITY DATA CENTER

## GOVERNMENT AGENCIES AND SERVICES SUPPORTED DIRECTLY AND INDIRECTLY BY AFMDC INQUIRIES

February 1, 1968 - September 30, 1968

### CATEGORY

A.	TOTAL INQUIRIES FOR THE PERIOD FEBRUARY 1, 1968 THROUGH SEPTEMBER 30, 1968	982
B.	INQUIRIES BY ACADEMIC AND COMMERCIAL SOURCES NOT IDENTIFIABLE WITH GOVERNMENT PURPOSES	47
C.	INQUIRIES IDENTIFIED AS SUPPORTING GOVERNMENT PURPOSES	935
D.	DIRECT INQUIRIES BY GOVERNMENT AGENCIES (USAF, NASA, etc.)	70
E.	INQUIRIES BY CONTRACTORS IDENTIFIED DIRECTLY WITH SPECIFIC GOVERNMENT SERVICES OR AGENCIES (USAF, NASA, etc.)	390
F.	INQUIRIES BY COMPANIES IDENTIFIED INDIRECTLY WITH SPECIFIC GOVERNMENT SERVICES OR AGENCIES (USAF, NASA, etc.)	475

	AIR FORCE	U.S. NAVY	U.S. ARMY	AEC	NASA	TOTAL
D. DIRECT INQUIRIES BY GOVERNMENT AGENCIES	28	9	9	20	6	70
E. INQUIRIES BY CONTRACTORS IDENTIFIED DIRECTLY WITH SPECIFIC GOVERNMENT SERVICES OR AGENCIES (USAF, NASA, etc.)	320	15	12	11	32	390
F. INQUIRIES BY COMPANIES IDENTIFIED INDIRECTLY WITH SPECIFIC GOVERNMENT SERVICES OR AGENCIES (USAF, NASA, etc.) TOTAL OF 475; DISTRIBUTION BY RATIO OR PRO- PORTION OF INQUIRIES COUNTED IN E ABOVE.	380	18	15	13	39	475
G. TOTAL TECHNICAL INQUIRIES ASSISTING GOVERNMENT PURPOSES	738	42	38	44	77	935



# **COMPANIES & AGENCIES SUBMITTING INQUIRIES TO AFMDC**

October 1, 1984 - January 31, 1988

ABEX CORPORATION, MAHWAH, N.J.  
 ABORN, DR. ROBERT H., MILLINGTON, N.J.  
 ACF INDUSTRIES, INC., ALBUQUERQUE, N.M.  
 ACCURATE BUSHING COMPANY, GARWOOD, N.J.  
 ACRALOC CORPORATION, OAK RIDGE, TENN.  
 ADAMAS CARBIDE CORP., KENILWORTH, N.J.  
 ADKINS & HUMINIK, ALEXANDRIA, VA.  
 AEROJET-GENERAL CORPORATION, AZUSA, CALIF.  
 AEROJET-GENERAL CORPORATION, CLAREMONT, CALIF.  
 AEROJET-GENERAL CORPORATION, DOWNEY, CALIF.  
 AEROJET-GENERAL CORPORATION, SACRAMENTO, CALIF.  
 AEROJET-GENERAL CORPORATION, DAYTON, OHIO  
 AERONCA INC., MIDDLETOWN, OHIO  
 AEROPROJECTS INC., WEST CHESTER, PA.  
 AEROQUIP CORPORATION, JACKSON, MICH.  
 AEROQUIP CORPORATION, VAN WERT, OHIO  
 AEROSPACE CORPORATION, SAN BERNARDINO, CALIF.  
 AEROSPACE RESEARCH APPLICATIONS CENTER,  
 BLOOMINGTON, IND.  
 AMERICAN INSTITUTE OF MINING METALLURGICAL &  
 PETROLEUM ENGINEERS, NEW YORK, N.Y.  
 AIR FORCE HEADQUARTER, WASHINGTON, D.C.  
 AIR FORCE REPRESENTATIVE, THE MARTIN CO.,  
 DENVER, COLO.  
 AIRESEARCH MANUFACTURING COMPANY, PHOENIX, ARIZ.  
 AIRESEARCH MANUFACTURING COMPANY, LOS ANGELES, CALIF.  
 ALLEGHENY-LUDLUM STEEL CORP., DUNKIRK, N.Y.  
 ALLEGHENY-LUDLUM STEEL CORP., PITTSBURGH, PA.  
 ALLIANCE TOOL COMPANY INC., ST. LOUIS, MO.  
 ALLIED CHEMICAL CORP., MORRISTOWN, N.J.  
 ALLIS-CHALMERS MANUFACTURING COMPANY, MILWAUKEE, WISC.  
 ALLIS-CHALMERS MANUFACTURING COMPANY, NORWOOD, OHIO  
 ALTAMIL CORPORATION, CHAMBERS AIRCRAFT DIV.,  
 SHELBYVILLE, IND.  
 ALUMINUM COMPANY OF AMERICA, LAFAYETTE, IND.  
 ALUMINUM COMPANY OF AMERICA, PITTSBURGH, PA.  
 ALUMINUM SMELTERS RESEARCH INSTITUTE, CHICAGO, ILL.  
 AMERICAN AIRLINES INC., TULSA, OKLA.  
 AMERICAN BOSCH ARMA CORPORATION, SPRINGFIELD, MASS.  
 AMERICAN BRAKE SHOE COMPANY, ELYRIA, OHIO  
 AMERICAN CYANAMID COMPANY, SANFORD, ME.  
 AMERICAN HELLER CORPORATION, DETROIT, MICH.  
 AMERICAN INSTITUTE OF AERONAUTICS, LOS ANGELES, CALIF.  
 AMERICAN LAUNDRY MACHINERY INDUSTRIES, CINCINNATI, OHIO  
 AMERICAN MACHINE & FOUNDRY CO., YORK, PA.  
 AMERICAN MACHINIST, CLEVELAND, OHIO  
 AMERICAN SAW & MANUFACTURING COMPANY, EAST LONGMEADOW,  
 MASS.  
 AMERICAN SOCIETY FOR METALS, METALS PARK, OHIO  
 AMERICAN SOCIETY OF TOOL & MANUFACTURING ENGINEERS,  
 DEARBORN, MICH.  
 AMERICAN TOOL WORKS, CINCINNATI, OHIO  
 AMERICAN WELDING & MANUFACTURING CO., WARREN, OHIO  
 AMES LABORATORY, AMES, IOWA  
 AMETEK INC., SELLERSVILLE, PA.  
 AMMUNITION PROCUREMENT & SUPPLY AGENCY, JOLIET, ILL.  
 AMPCO METAL INC., MILWAUKEE, WISC.  
 AMPHENOL CORPORATION, CHICAGO, ILL.  
 ANDERSON BROTHERS MANUFACTURING CO., ROCKFORD, ILL.  
 ANDREWS AIR FORCE BASE, WASHINGTON, D.C.  
 ANOCUT ENGINEERING COMPANY, ELK GROVE VILLAGE, ILL.  
 APEX CORPORATION, INDIANAPOLIS, IND.  
 API CORPORATION, MIAMI, FLA.  
 ARGONNE NATIONAL LABORATORY, ARGONNE, ILL.  
 ARIZONA, UNIVERSITY OF, TUCSON, ARIZ.  
 ARKWIN INDUSTRIES INC., WESTBURY, N.Y.  
 ARMCO STEEL CORPORATION, BALTIMORE, MD.  
 ARMCO STEEL CORPORATION, CINCINNATI, OHIO  
 ARMCO STEEL CORPORATION, MIDDLETOWN, OHIO  
 ARMCO STEEL CORPORATION, TORRANCE, CALIF.  
 ARMSTRONG BLUM MFG. COMPANY, CINCINNATI, OHIO  
 ARMY PROCUREMENT DISTRICT, CHICAGO, ILL.

ARO, INC., ARNOLD AIR FORCE STATION, TENN.  
 ARROW GEAR COMPANY, DOWNERS GROVE, ILL.  
 ARROWSMITH TOOL & MFG. CORP., LOS ANGELES, CALIF.  
 ASTROSYSTEMS INTERNATIONAL INC., ROCKAWAY, N.J.  
 ATLANTIC RESEARCH CORPORATION, GAINESVILLE, VA.  
 ATLANTIC RICHFIELD COMPANY, PHILADELPHIA, PA.  
 ATLAS ALLOYS, CLEVELAND, OHIO  
 AUTOMATION ACCESSORIES INC., CINCINNATI, OHIO  
 AUTOMATION ACCESSORIES INC., DAYTON, OHIO  
 AUTOMATION INDUSTRIES INC., ABILENE, TEX.  
 AUTOMOTIVE SERVICENTER INC., BALTIMORE, MD.  
 AVCO CORPORATION, STRATFORD, CONN.  
 AVCO CORPORATION, RICHMOND, IND.  
 AVCO CORPORATION, WILMINGTON, MASS.  
 AVCO CORPORATION, COLDWATER, OHIO  
 AVCO CORPORATION, NASHVILLE, TENN.  
 AVEY MACHINE TOOL COMPANY, COVINGTON, KY.  
 AVILDSSEN TOOL & MACHINES INC., NEW YORK, N.Y.  
 BACHAN MANUFACTURING CO., POMPANO BEACH, FLA.  
 BACKER TOOL & DIE, CINCINNATI, OHIO  
 BADGER, F. SIDNEY, WOODLAND HILLS, CALIF.  
 BADGETT & SMITH ASSOCIATES INC., CINCINNATI, OHIO  
 BAKER OIL TOOLS INC., LOS ANGELES, CALIF.  
 BALDWIN-LIMA-HAMILTON, BURNHAM, PA.  
 BATTELLE MEMORIAL INSTITUTE, COLUMBUS, OHIO  
 BATTELLE MEMORIAL INSTITUTE, RICHLAND, WASH.  
 BATTELLE MEMORIAL INSTITUTE, LOS ANGELES, CALIF.  
 BAUSCH & LOMB INCORPORATED, ROCHESTER, N.Y.  
 BDSA DEPARTMENT OF COMMERCE, WASHINGTON, D.C.  
 BEECH AIRCRAFT CO., WICHITA, KAN.  
 BELL HELICOPTER COMPANY, FT. WORTH, TEX.  
 BELL & HOWELL RESEARCH CENTER, PASADENA, CALIF.  
 BELLOWES-VALVAIR CORPORATION, CINCINNATI, OHIO  
 BELOIT CORPORATION, BELOIT, WISC.  
 BELOIT EASTERN CORPORATION, DOWNINGTON, PA.  
 BENDIX CORPORATION (THE), DETROIT, MICH.  
 BENDIX CORPORATION (THE), SOUTHFIELD, MICH.  
 BENDIX CORPORATION (THE), KANSAS CITY, MO.  
 BENDIX CORPORATION (THE), TETERBORO, N.J.  
 BENDIX CORPORATION (THE), SIDNEY, N.Y.  
 BENDIX CORPORATION (THE), YORK, PA.  
 BENDIX CORPORATION (THE), SOUTH BEND, IND.  
 BENEDICT-MILLER INC., LYNDBURST, N.J.  
 BENNET TECHNICAL SERVICES INC., CINCINNATI, OHIO  
 BENRUS WATCH COMPANY, WATERBURY, CONN.  
 BERCO MANUFACTURING COMPANY, WATERBURY, CONN.  
 BERYLLIUM CORPORATION OF AMERICA (THE),  
 READING, PA.  
 BERYLLIUM CORPORATION OF AMERICA (THE),  
 HAZELTON, PA.  
 BESLY-WELLES CORPORATION, SOUTH BELOIT, ILL.  
 BESLY-WELLES CORPORATION, CINCINNATI, OHIO  
 BETHLEHEM STEEL CORPORATION, BETHLEHEM, PA.  
 BIGGER COMPANY, C. M., READING, OHIO  
 BLACK & DECKER MFG. CO., TOWSON, MD.  
 BLISS COMPANY, E. W., SOUTH PORTLAND, ME.  
 BOEING COMPANY (THE), WICHITA, KAN.  
 BOEING COMPANY (THE), NEW ORLEANS, LA.  
 BOEING COMPANY (THE), RENTON, WASH.  
 BOEING COMPANY (THE), SEATTLE, WASH.  
 BOEING COMPANY (THE), PHILADELPHIA, PA.  
 BOEING COMPANY (THE), AUBURN, WASH.  
 BOMAR COMPANY, CINCINNATI, OHIO  
 BOOZ ALLEN APPLIED RESEARCH INC., NEW YORK, N.Y.  
 BORG-WARNER CORPORATION, FREMONT, OHIO  
 BORG-WARNER CORPORATION, CHICAGO, ILL.  
 BOSTROM CORPORATION, MILWAUKEE, WISC.  
 BRAD FOOTE GEAR WORKS INC., CICERO, ILL.  
 BRANDS MACHINING COMPANY, PORTLAND, PA.  
 BRASS & BRONZE INSTITUTE, CHICAGO, ILL.

BRIDGEPORT, UNIVERSITY OF, BRIDGEPORT, CONN.  
 BRIGGS & STRATTON CORPORATION, MILWAUKEE, WISC.  
 BRIGHAM YOUNG UNIVERSITY, PROVO, UTAH  
 BROOKS & PERKINS INC., DETROIT, MICH.  
 BROWN & ROOT INC., HOUSTON, TEX.  
 BROWN & SHARPE MANUFACTURING CO., DAYTON, OHIO  
 BRUBAKER TOOL CORPORATION, MILLERSBURG, PA.  
 BRUNSWICK CORPORATION, MUSKEGON, MICH.  
 BRUSH BERYLLIUM COMPANY (THE), HAYWARD, CALIF.  
 BRUSH BERYLLIUM COMPANY (THE), CLEVELAND, OHIO  
 BRUSH BERYLLIUM COMPANY (THE), ELMORE, OHIO  
 BUCKEYE FOUNDRY COMPANY, CINCINNATI, OHIO  
 BUDD COMPANY, NEWARK, DELA.  
 BUERK TOOL & MACHINE CORPORATION, BUFFALO, N.Y.  
 BUHR MACHINE TOOL COMPANY, DETROIT, MICH.  
 BULLARD COMPANY, (THE), BRIDGEPORT, CONN.  
 BUNKER-RAMO CORPORATION, CLEVELAND, OHIO  
 BURGESS-NORTON MANUFACTURING CO., GENEVA, ILL.  
 BURGMASER CORPORATION, CINCINNATI, OHIO  
 BURNDY CORPORATION, NORWALK, CONN.  
 BURSON MARSTELLER ASSOCIATES, NEW YORK, N.Y.

CADILLAC GAGE COMPANY, ROSEVILLE, MICH.  
 CALIFORNIA STATE PRISON, SAN QUENTIN, CALIF.  
 CALIFORNIA GENERAL INC., CHULA VISTA, CALIF.  
 CAMCAR SCREW & MANUFACTURING CO., ROCKFORD, ILL.  
 CAMERON IRON WORKS, HOUSTON, TEX.  
 CARBORUNDUM COMPANY (THE), NIAGARA FALLS, N.Y.  
 CARLISLE CHEMICAL WORKS INC., READING, OHIO  
 CARNEGIE INSTITUTE OF TECHNOLOGY, PITTSBURGH, PA.  
 CARPENTER STEEL COMPANY (THE), READING, PA.  
 CARR TOOL COMPANY, NORWOOD, OHIO  
 CARRIER AIR CONDITIONING CO., SYRACUSE, N.Y.  
 CATERPILLAR TRACTOR COMPANY, DECATUR, ILL.  
 CATERPILLAR TRACTOR COMPANY, PEORIA, ILL.  
 CAVITRON ULTRASONICS, INC., LONG ISLAND, N.Y.  
 CDS ENGINEERING INC., SANTA CLARA, CALIF.  
 CEEMCO, CINCINNATI, OHIO  
 CELANESE FIBERS COMPANY, NARROWS, VA.  
 CENTRAL MACHINE WORKS, INDIANAPOLIS, IND.  
 CENTRO CORPORATION, DAYTON, OHIO  
 CENTRAL FABRICATORS INC., CINCINNATI, OHIO  
 CHAMBERLAIN MANUFACTURING CORPORATION,  
 WATERLOO, IOWA  
 CHANDLER EVANS INC., WEST HARTFORD, CONN.  
 CHASE BRASS & COPPER CO., SOLON, OHIO  
 CHASE MANHATTAN BANK, NEW YORK, N.Y.  
 CHICAGO CUTTING DIE COMPANY, CHICAGO, ILL.  
 CHICAGO PROCUREMENT DETACHMENT, CHICAGO, ILL.  
 CHRYSLER CORPORATION, NEW ORLEANS, LA.  
 CHRYSLER CORPORATION, DEARBORN, MICH.  
 CHUCKING MACHINE PRODUCTS INC., FRANKLIN PARK, ILL.  
 CINCINNATI LATHE & TOOL COMPANY, CINCINNATI, OHIO  
 CINCINNATI MILLING MACHINE COMPANY (THE),  
 CINCINNATI, OHIO

CINCINNATI MINE MACHINERY CO., CINCINNATI, OHIO  
 CINCINNATI SHAPER COMPANY, WHITEWATER, OHIO  
 CINCINNATI SUB-ZERO PRODUCTS INC., CINCINNATI, OHIO  
 CINCINNATI, UNIVERSITY OF, CINCINNATI, OHIO  
 CITRUS COLLEGE, AZUSA, CALIF.  
 CLEARINGHOUSE FOR FEDERAL SCIENTIFIC & TECHNICAL  
 INFORMATION, SPRINGFIELD, VA.  
 CLEVELAND AUTOMATIC MACHINE TOOL CO., CINCINNATI, OHIO  
 CLEVELAND PNEUMATIC TOOL CO., (THE), CLEVELAND, OHIO  
 CLEVELAND TWIST DRILL COMPANY, CLEVELAND, OHIO  
 CLEVITE CORPORATION, CLEVELAND, OHIO  
 CLIMCO PRODUCTS INC., CINCINNATI, OHIO  
 COBALT INFORMATION CENTER, COLUMBUS, OHIO  
 COLLINS RADIO COMPANY, CEDAR RAPIDS, IOWA  
 COLLINS RADIO COMPANY, DALLAS, TEX.  
 COLT INDUSTRIES INC., BELDIT, WISC.  
 COMSTOCK & WESCOTT INC., CAMBRIDGE, MASS.  
 CONCORD-RENN COMPANY, CINCINNATI, OHIO  
 CONTINENTAL AVIATION & ENGINEERING CORP.,  
 DETROIT, MICH.  
 CONTINENTAL AVIATION & ENGINEERING CORP.,  
 TOLEDO, OHIO  
 CONTINENTAL COPPER & STEEL CO., BRAEBURN, PA.

CONTINENTAL-EMSCO COMPANY, GARLAND, TEX.  
 CONTINENTAL MOTORS CORPORATION, MUSKEGON, MICH.  
 CONTINENTAL TOOL COMPANY, DETROIT, MICH.  
 CONTROLS COMPANY OF AMERICA, JACKSONVILLE, ARK.  
 CONVER STEEL & WIRE CO. INC., NEW YORK, N.Y.  
 COORS CO., INC., H. F., INGLEWOOD, CALIF.  
 COONS PORCELAIN COMPANY, GOLDEN, COLO.  
 CORHART REFRACTORIES COMPANY, BUCHANON, W. VA.  
 CORNELL AERONAUTICAL LABORATORY INC., BUFFALO, N.Y.  
 CORNING GLASS WORKS, CORNING, N.Y.  
 CORPLAN ASSOCIATES, CHICAGO, ILL.  
 CRAFTNEEDS INC., CINCINNATI, OHIO  
 CRANE CO., NEW CASTLE, PA.  
 CRUCIBLE STEEL COMPANY OF AMERICA, CINCINNATI, OHIO  
 CRUCIBLE STEEL COMPANY OF AMERICA, PITTSBURGH, PA.  
 CUMMINS ENGINE COMPANY INC., COLUMBUS, IND.  
 CURTISS-WRIGHT CORP., CALDWELL, N.J.  
 CURTISS-WRIGHT CORP., WOOD-RIDGE, N.J.  
 CURTISS-WRIGHT CORP., BUFFALO, N.Y.  
 CUSTOM TOOLING CO., CINCINNATI, OHIO  
 CYCLOPS CORPORATION (UNIVERSAL CYCLOPS),  
 BRIDGEVILLE, PA.

DALMO VICTOR COMPANY, BELMONT, CALIF.  
 DATA INFORMATION GATHERING SERVICE, PALO ALTO,  
 CALIF.  
 DAVEWOOD SUPPLY COMPANY, ROCKFORD, ILL.  
 DAYTON MALLEABLE IRON CO., DAYTON, OHIO  
 DAYTON RESEARCH INSTITUTE, UNIVERSITY OF, DAYTON,  
 OHIO  
 DEERE & COMPANY, MOLINE, ILL.  
 DEFENSE CERAMIC INFORMATION CENTER, COLUMBUS,  
 OHIO  
 DEL MACHINE & WELDING WORKS INC., HOUSTON, TEX.  
 DEPUY MANUFACTURING COMPANY, WARSAW, IND.  
 DETROIT BROACH & MACHINE CO., ROCHESTER, MICH.  
 DEUTSCH COMPANY, LOS ANGELES, CALIF.  
 DIAMOND ALKALI COMPANY, PAYNESVILLE, OHIO  
 DIAMOND, TOOLS & ABRASIVES INC., JUPITER, FLA.  
 DIAMONITE PRODUCTS MANUFACTURING CO., SHREVE, OHIO  
 D-K PRODUCTS (DIV. SYMINGTON WAYNE CORP.),  
 CHICAGO, ILL.  
 D-M-E CORPORATION, DETROIT, MICH.  
 DO-ALL COMPANY, DES PLAINES, ILL.  
 DOVER CORPORATION, LOUISVILLE, KY.  
 DOVER CORPORATION, CINCINNATI, OHIO  
 DOW CHEMICAL COMPANY (THE), DENVER, COLO.  
 DOW CHEMICAL COMPANY (THE), GOLDEN, COLO.  
 DOW CHEMICAL COMPANY, (THE), MIDLAND, MICH.  
 DREW CHEMICAL CORPORATION, BOONTON, N.J.  
 DREXEL INSTITUTE OF TECHNOLOGY, PHILADELPHIA, PA.  
 DUMORE COMPANY, RACINE, WISC.  
 DUNCAN MANUFACTURING CO., CINCINNATI, OHIO  
 DUPONT DENEMOURS & CO. INC., E. I., WILMINGTON, DEL  
 DUPONT DENEMOURS & CO. INC., E. I., MARTINSVILLE, V  
 DYNA-TECH INC., DECATUR, ALA.

EASTERN KENTUCKY UNIVERSITY, RICHMOND, KY.  
 EASTMAN KODAK COMPANY, ROCHESTER, N.Y.  
 EATON YALE & TOWN INC., SOUTH EUCLID, OHIO  
 EATON YALE & TOWN INC., SABINAW, MICH.  
 ECIVRES INC., NORWOOD, OHIO  
 EDMUNDS MANUFACTURING CO., FARMINGTON, CONN.  
 EIS AUTOMOTIVE CORPORATION (THE), MIDDLETOWN, CONN.  
 EITEL-MCCULLOUGH INC., SAN CARLOS, CALIF.  
 ELANO CORPORATION, XENIA, OHIO  
 ELASTIC STOP-NUT CORP. OF AMERICA, UNION, N.J.  
 ELECTRIC STORAGE BATTERY COMPANY (THE),  
 PHILADELPHIA, PA.  
 ELECTRICAL MACHINING INC., CINCINNATI, OHIO  
 ELECTRO-JET TOOL COMPANY, CINCINNATI, OHIO  
 ELECTRONIC SPECIALTY COMPANY, PORTLAND, ORE.  
 ELLIOTT COMPANY, JEANNETTE, PA.  
 ELOX CORP. OF MICHIGAN, TROY, MICH.  
 EMERSON ELECTRIC COMPANY, LOS ANGELES, CALIF.  
 EMERSON ELECTRIC COMPANY, ST. LOUIS, MO.  
 EMI, CINCINNATI, OHIO  
 ENGINEERING SOCIETIES LIBRARY, NEW YORK, N.Y.  
 ENTWISTLE MANUFACTURING CO., PROVIDENCE, R. I.

ERIE INDUSTRIES INC., FERNDAL, MICH.  
 ERNST, HANS, CLEARWATER, FLA.  
 ESABE MANUFACTURING CO. INC., FT. LAUDERDALE, FLA.  
 ESCO CORPORATION, LOS ANGELES, CALIF.  
 ESSO RESEARCH & ENGINEERING CO., LINDEN, N.J.  
 EUCLID MACHINE CO., INC., INDIANAPOLIS, IND.  
 EX-CELL-O CORPORATION, LIMA, OHIO  
  
 FAFNIR BEARING COMPANY (THE), NEW BRITAIN, CONN.  
 FAIRCHILD HILLER CORPORATION, ROCKVILLE, MD.  
 FAIRCHILD HILLER CORPORATION, FARMINGDALE, L.I., N.Y.  
 FAIRCHILD PRECISION METALS PRODUCTS, EL CAJON, CALIF.  
 FANSTEEL METALLURGICAL CORP., NO. CHICAGO, ILL.  
 FELLOWS GEAR SHAPER COMPANY (THE), SPRINGFIELD, VT.  
 FERGUSON MACHINE COMPANY, TOLEDO, OHIO  
 FERRIS STATE COLLEGE, BIG RAPIDS, MICH.  
 FERROTHERM CO., CLEVELAND, OHIO  
 FIBERITE CORPORATION, WINONA, WISC.  
 FIRESTONE TIRE & RUBBER CO. (THE), AKRON, OHIO  
 FIREWEL COMPANY INC. (THE), BUFFALO, N.Y.  
 FISCHER GOVERNOR COMPANY, MARSHALLTOWN, IOWA  
 FLICK-REEDY CORPORATION, BENSENVILLE, IND.  
 FMC CORPORATION, SAN JOSE, CALIF.  
 FORD MOTOR COMPANY, DEARBORN, MICH.  
 FORD MOTOR COMPANY, METAL STAMPING, DEARBORN, MICH.  
 FORD MOTOR COMPANY, LIVONIA, MICH.  
 FORD MOTOR COMPANY, FAIRFAX PLANT, CINCINNATI, OHIO  
 FORD MOTOR COMPANY, SHARONVILLE PLANT, CINCINNATI, OHIO  
 FRANKFORD ARSENAL, PHILADELPHIA, PA.  
 FRANKLIN BALMAR CORPORATION, BALTIMORE, MD.  
 FRANKLIN ELECTRIC CO., INC., BLUFFTON, IND.  
 FRANKLIN OIL CORPORATION, BEDFORD, OHIO  
 FULLER MERRIAM COMPANY, WEST HAVEN, CONN.  
 FYR-FYTER COMPANY (THE), NEWARK, N.J.  
 G & O TOOL & DIE COMPANY, BEECHGROVE, IND.  
 GALT COMPANY, KENNETH J., INDIANAPOLIS, IND.  
 GARDNER MACHINE COMPANY, SOUTH BELOIT, ILL.  
 GAR-KENYON INSTRUMENTS INC., BREWSTER, N.Y.  
 GEBEL INDUSTRIES, CINCINNATI, OHIO  
 GENERAL DYNAMICS CORP., SAN DIEGO, CALIF.  
 GENERAL DYNAMICS CORP., GROTON, CONN.  
 GENERAL DYNAMICS CORP., NEW YORK, N.Y.  
 GENERAL DYNAMICS CORP., FT. WORTH, TEX.  
 GENERAL ELECTRIC COMPANY, PHOENIX, ARIZ.  
 GENERAL ELECTRIC COMPANY, PLEASANTOWN, CALIF.  
 GENERAL ELECTRIC COMPANY, SAN JOSE, CALIF.  
 GENERAL ELECTRIC COMPANY, DAYTONA BEACH, FLA.  
 GENERAL ELECTRIC COMPANY, BLOOMINGTON, ILL.  
 GENERAL ELECTRIC COMPANY, FT. WAYNE, IND.  
 GENERAL ELECTRIC COMPANY, LOUISVILLE, KY.  
 GENERAL ELECTRIC COMPANY, EVERETT, MASS.  
 GENERAL ELECTRIC COMPANY, LYNN, MASS.  
 GENERAL ELECTRIC COMPANY, DETROIT, MICH.  
 GENERAL ELECTRIC COMPANY, WARREN, MICH.  
 GENERAL ELECTRIC COMPANY, KAPL, SCHENECTADY, N.Y.  
 GENERAL ELECTRIC COMPANY, SCHENECTADY, N.Y.  
 GENERAL ELECTRIC COMPANY, SYRACUSE, N.Y.  
 GENERAL ELECTRIC COMPANY, UTICA, N.Y.  
 GENERAL ELECTRIC COMPANY, WATERFORD, N.Y.  
 GENERAL ELECTRIC COMPANY, CINCINNATI, OHIO  
 GENERAL ELECTRIC COMPANY, CLEVELAND, OHIO  
 GENERAL ELECTRIC COMPANY, DAYTON, OHIO  
 GENERAL ELECTRIC COMPANY, ERIE, PA.  
 GENERAL ELECTRIC COMPANY, KING OF PRUSSIA, PA.  
 GENERAL ELECTRIC COMPANY, PHILADELPHIA, PA.  
 GENERAL ELECTRIC COMPANY, VALLEY FORGE SPACE TECHNOLOGY CENTER, PHILADELPHIA, PA.  
 GENERAL ELECTRIC COMPANY, BURLINGTON, VT.  
 GENERAL ELECTRIC COMPANY, RUTLAND, VT.  
 GENERAL ELECTRIC COMPANY, WAYNESBORO, VA.  
 GENERAL ELECTRIC COMPANY, SOMERSBORO, N.H.  
 GENERAL ELECTRIC COMPANY, SUNNYVALE, CALIF.

GENERAL ELECTRO-MECH CORP., BUFFALO, N.Y.  
 GENERAL MOTORS CORPORATION DEFENSE RESEARCH LAB., SANTA BARBARA, CALIF.  
 GENERAL MOTORS CORPORATION, DELCO REMY DIVISION, ANDERSON, IND.  
 GENERAL MOTORS CORPORATION GUIDE LAMP DIVISION, ANDERSON, IND.  
 GENERAL MOTORS CORPORATION, INDIANAPOLIS, INC.  
 GENERAL MOTORS CORPORATION, MUNICE, IND.  
 GENERAL MOTORS INSTITUTE, FLINT, MICH.  
 GENERAL MOTORS CORPORATION, WARREN, MICH.  
 GENERAL MOTORS CORPORATION, HARRISON, N.J.  
 GENERAL MOTORS CORPORATION, FRIGIDAIRE DIVISION, DAYTON, OHIO  
 GENERAL MOTORS CORPORATION, INLAND MANUFACTURING DAYTON, OHIO  
 GENERAL MOTORS CORPORATION, MILWAUKEE, WISC.  
 GENERAL PRECISION AEROSPACE TECHNICAL INFORMATION CENTER, LITTLE FALLS, N.J.  
 GENERAL PRECISION INCORPORATED, BINGHAMTON, N.Y.  
 GENERAL PRECISION INCORPORATED, PLEASANTVILLE, N.Y.  
 GENERAL TRANSDUCER COMPANY, SANTA CLARA, CALIF.  
 GEOMETRIC TOOL COMPANY, NEW HAVEN, CONN.  
 GEORGE'S SCREW PRODUCTS, FRANKLIN PARK, ILL.  
 GISHOLT CORPORATION, MADISON, WISC.  
 GLIDDEN COMPANY (THE), BALTIMORE, MD.  
 GODDARD SPACE FLIGHT CENTER, GREENBELT, MD.  
 GOLDMAN & COMPANY, HARTFORD, DEARBORN, MICH.  
 GOODRICH COMPANY, B. F., AKRON, OHIO  
 GOODYEAR AEROSPACE CORPORATION, AKRON, OHIO  
 GOULDS PUMPS INC., SENECA FALLS, N.Y.  
 GRAHAM RESEARCH LABORATORY, PITTSBURGH, PA.  
 GRAY COMPANY, G. A., CINCINNATI, OHIO  
 GREAT LAKES RESEARCH CORPORATION, ELIZABETHTON, TENN.  
 GREAT LAKES STEEL CORPORATION, DETROIT, MICH.  
 GREENFIELD TAP & DIE, GREENFIELD, MASS.  
 GREENLEAF CORPORATION, HAGERSTOWN, PA.  
 GRIFFIN WHEEL COMPANY, CHICAGO, ILL.  
 GRIKO CHEMICAL PRODUCTS INC., NEWARK, N.J.  
 GRISWOLD-ESHLEMAN COMPANY (THE), CLEVELAND, OHIO  
 GRUMMAN AIRCRAFT ENGINEERING CORP., BETHPAGE, L.I. N.Y.  
 GULF COAST TECHNICAL INSTITUTE, GULFPORT, MISS.  
  
 H & C SUPPLY CORPORATION, ROCHESTER, N.Y.  
 HALL PLANETARY CO. OF PHILADELPHIA, PHILADELPHIA, PA.  
 HAMILTON STANDARD, WINDSOR LOCKS, CONN.  
 HAMILTON TOOL & MACHINE CO., KENILWORTH, N.J.  
 HANNISCHFEGGER COMPANY, ESCANABA, MICH.  
 HARRIS-INTERTYPE CORPORATION, CLEVELAND, OHIO  
 HARVARD BUSINESS SCHOOL, CAMBRIDGE, MASS.  
 HARVEY ALUMINUM SALES INC., EAST ORANGE, N.J.  
 HASTINGS MANUFACTURING CO., HASTINGS, MICH.  
 HATER INDUSTRIES, CINCINNATI, OHIO  
 HEALD MACHINE COMPANY, WORCESTER, MASS.  
 HENDRIKSEN, ERIC, DOWNEY, CALIF.  
 HERCULES INC., ALLEGANY BALLISTICS LAB., CUMBERLAND, MARYLAND  
 HERBERT PRODUCTS COMPANY, CHICAGO, ILL.  
 HESSTON CORPORATION, HESSTON, KAN.  
 HILL, GEORGE M., OXFORD, OHIO  
 HINCLE BROTHERS INC., CLARKSBURG, W. VA.  
 HIRSCHMANN CORPORATION, ROSLYN HEIGHTS, N.Y.  
 HOSART MANUFACTURING COMPANY, TROY, OHIO  
 HOFFMAN BROTHERS JEWELRY CO., TUNESUTABNEY, PA.  
 HORE INC., CRESSKILL, N.J.  
 HOLLEY CARBURETOR COMPANY, WARREN, MICH.  
 HOLLEY CARBURETOR COMPANY, CLARE, MICH.  
 HOLYOKE MACHINE COMPANY, HOLYOKE, MASS.  
 HONEYWELL INC., ST. PETERSBURG, FLA.  
 HONEYWELL INC., NEW BRIGHTON, MINN.

HONEYWELL INC., MINNEAPOLIS, MINN.  
 HOUGHTON COMPANY, E. F., CINCINNATI, OHIO  
 HOUGHTON COMPANY, E. F., CLEVELAND, OHIO  
 HOUSTON, UNIVERSITY OF, HOUSTON, TEX.  
 HUCKTROL INC., KINGSTON, N.Y.  
 HUGHES AIRCRAFT COMPANY, CULVER CITY, CALIF.  
 HUGHES AIRCRAFT COMPANY, EL SEGUNDO, CALIF.  
 HUGHES AIRCRAFT COMPANY, LOS ANGELES, CALIF.  
 HUGHES AIRCRAFT COMPANY, TUCSON, ARIZ.  
 HUGHES TOOL COMPANY, CULVER CITY, CALIF.  
 HUMBLE OIL & REFINING CO., HOUSTON, TEX.  
 HYDRAULIC RESEARCH & MANUFACTURING CO.,  
 BURBANK, CALIF.  
 HYDRODYNE ENGINEERING COMPANY, SANTA ANA, CALIF.  
 HYSTER COMPANY, PORTLAND, ORE.  
 HYSTER COMPANY, DANVILLE, ILL.

IIT RESEARCH INSTITUTE, CHICAGO, ILL.  
 ITT CANNON ELECTRIC INC., LOS ANGELES, CALIF.  
 ILLINOIS INSTITUTE OF TECHNOLOGY, CHICAGO, ILL.  
 ILLINOIS, STATE OF, SPRINGFIELD, ILL.  
 ILLINOIS, UNIVERSITY OF, URBANA, ILL.  
 INDUSTRIAL NUCLEONICS CORP., COLUMBUS, OHIO  
 INGERSOLL MILLING MACHINE CO. (THE), ROCKFORD, ILL.  
 INGERSOLL RAND COMPANY, PHILIPSBURG, N.J.  
 INGERSOLL RAND COMPANY, PRINCETON, N.J.  
 INGERSOLL RAND COMPANY, PAINTED POST, N.Y.  
 INSTITUTE OF GAS TECHNOLOGY, CHICAGO, ILL.  
 INTERNATIONAL BUSINESS MACHINES CORP., LEXINGTON, KY.  
 INTERNATIONAL BUSINESS MACHINES CORP., ROCKVILLE, MD.  
 INTERNATIONAL BUSINESS MACHINES CORP., ENDICOTT, N.Y.  
 INTERNATIONAL BUSINESS MACHINES CORP., KINGSTON, N.Y.  
 INTERNATIONAL BUSINESS MACHINES CORP., OWEGO, N.Y.  
 INTERNATIONAL BUSINESS MACHINES CORP., Poughkeepsie, N.Y.  
 INTERNATIONAL BUSINESS MACHINES CORP., YORKTOWN HEIGHTS,  
 N.Y.  
 INTERNATIONAL BUSINESS MACHINES CORP., DAYTON, OHIO  
 INTERNATIONAL GLASS COMPANY, NEW YORK, N.Y.  
 INTERNATIONAL HARVESTER COMPANY, CHICAGO, ILL.  
 INTERNATIONAL LEAD ZINC RESEARCH ORGANIZATION INC.,  
 NEW YORK, N.Y.  
 INTERNATIONAL NICKEL CO., INC. (THE), NEW YORK, N.Y.  
 INTERNATIONAL NICKEL CO., INC. (THE), SUFFERN, N.Y.  
 INTERNATIONAL NICKEL CO., INC. (THE), DAYTON, OHIO  
 INTERNATIONAL NICKEL CO., INC. (THE), HUNTINGTON, W. VA.  
 ION PHYSICS CORPORATION, BURLINGTON, MASS.  
 IOWA STATE UNIVERSITY OF SCIENCE & TECHNOLOGY,  
 AMES, IOWA  
 IOWA, UNIVERSITY OF, IOWA CITY, IOWA  
 IRON AGE, PHILADELPHIA, PA.

JANSSEN MANUFACTURING COMPANY, WAYNESVILLE, OHIO  
 JARVIS CORPORATION, PORTLAND, CONN.  
 JARVIS CORPORATION, GREENWOOD, S.C.  
 JERDEN MANUFACTURING COMPANY, INDIANAPOLIS, IND.  
 JET PRODUCTS CORPORATION, SAN DIEGO, CALIF.  
 JONES & LAMSON, SPRINGFIELD, VT.  
 JONES & LAUGHLIN STEEL CORP., INDIANAPOLIS, IND.  
 JORDON VALVE, CINCINNATI, OHIO

KDI COMPANY, CINCINNATI, OHIO  
 KAISER AEROSPACE & ELECTRONICS, SAN LEANDRO, CALIF.  
 KANSAS STATE COLLEGE OF PITTSBURGH, PITTSBURGH, KAN.  
 KARL & SONS, WILLIAM, MIDDLE VILLAGE, N.Y.  
 KEARNEY & CO., INC., A.T., CHICAGO, ILL.  
 KEARNEY & TRECHER, MILWAUKEE, WISC.  
 KEMETRIC COMPANY, SUNNYVALE, CALIF.  
 KENNAMETAL INC., CINCINNATI, OHIO  
 KENNAMETAL INC., BEDFORD, PA.  
 KENNAMETAL INC., LATROBE, PA.  
 KENNEDY SPACE CENTER, KENNEDY SPACE CENTER, FLA.  
 KENT STATE UNIVERSITY, KENT, OHIO  
 KERNS MANUFACTURING CO., LONG ISLAND CITY, N.Y.

KING FIFTH WHEEL COMPANY, MOUNTAINTOP, PA.  
 KINSEY COMPANY, E. A., CINCINNATI, OHIO  
 KLIK INDUSTRIES, HARTFORD, CONN.  
 KLINE MANUFACTURING CO., WESTERVILLE, OHIO  
 KOBE INC., HUNTINGTON PARK, CALIF.  
 KOEHRING CO., HPM DIVISION, MT. GILEAD, OHIO  
 KOPPERS COMPANY INC., BALTIMORE, MD.  
 KREISLER INDUSTRIAL CORP., EAST PATTERSON, N.J.  
 KRESS CORPORATION, CLEVELAND, OHIO  
 KRONENBERG, DR. MAX, CINCINNATI, OHIO  
 KUNTZ COMPANY, J. R., DAYTON, OHIO

LADISH COMPANY, CUDAHY, WISC.  
 LANCASTER METAL PRODUCTS, LANCASTER, OHIO  
 LASALLE STEEL COMPANY, HAMMOND, IND.  
 LATROBE STEEL COMPANY, LATROBE, PA.  
 LAVALLEE & IDE INC., CHICOPEE, MASS.  
 LAVIN & SONS, INC., R. CHICAGO, ILL.  
 LAWRENCE AVIATION INDUSTRIES, INC., NEW YORK,  
 N.Y.  
 LAWRENCE RADIATION LABORATORY, LIVERMORE, CALIF.  
 LEAR SIEGLER COMPANY, GRAND RAPIDS, MICH.  
 LEBANON STEEL FOUNDRY, LEBANON, PA.  
 LEBLOND MACHINE TOOL COMPANY, R. K., CINCINNATI,  
 OHIO  
 LEHIGH UNIVERSITY, BETHLEHEM, PA.  
 LELAND-GIFFORD COMPANY, WORCESTER, MASS.  
 LENNOR ENGINEERING COMPANY, CHICAGO, ILL.  
 LESSELLS AND ASSOCIATES, WALTHAM, MASS.  
 LINAIR ENGINEERING, DANIA, FLA.  
 LING-TEMCO-VOUGHT, INC., DALLAS, TEX.  
 LING-TEMCO-VOUGHT (LTV AEROSPACE) WARREN, MICH.  
 LING-TEMCO-VOUGHT (LTV ELECTROSYSTEMS),  
 GREENVILLE, TEX.  
 LINK BELT COMPANY, INDIANAPOLIS, IND.  
 LINK BELT COMPANY, PHILADELPHIA, PA.  
 LIQUID DYNAMICS, CHICAGO, ILL.  
 LITTLE CO., INC., ARTHUR D., CAMBRIDGE, MASS.  
 LLOYD PRODUCTS COMPANY, CINCINNATI, OHIO  
 LOCKHEED AIRCRAFT CORPORATION, BURBANK, CALIF.  
 LOCKHEED AIRCRAFT CORPORATION, PALO ALTO, CALIF.  
 LOCKHEED AIRCRAFT CORPORATION, REDLANDS, CALIF.  
 LOCKHEED AIRCRAFT CORPORATION, SUNNYVALE, CALIF.  
 LOCKHEED-GEORGIA COMPANY MARIETTA, GA.  
 LODGE & SHIPLEY COMPANY (THE), CINCINNATI, OHIO  
 LONGYEAR COMPANY, E. J., MINNEAPOLIS, MINN.  
 LORD MANUFACTURING COMPANY, ERIE, PA.  
 LOUD COMPANY, H. W., POMONA, CALIF.  
 LUBEX PRODUCTS INC., NORTH ATTLEBORO, MASS.  
 LUNKENHEIMER COMPANY, CINCINNATI, OHIO

MSAR INC., IRWIN, PA.  
 MACHINE DESIGN, CLEVELAND, OHIO  
 MACHINECRAFT, INC., BALTIMORE, MD.  
 MACHINERY, BIRMINGHAM, MICH.  
 MACHINING TECHNOLOGY CORPORATION, SO. WINDSOR,  
 CONN.  
 MACLIN COMPANY, JACKSON, MICH.  
 MADISON INDUSTRIES, PROVIDENCE, R.I.  
 MAFFITT TOOL & MACHINE COMPANY, ST. LOUIS, MO.  
 MAGNA MACHINE COMPANY, CINCINNATI, OHIO  
 MALLEABLE FOUNDERS SOCIETY, CLEVELAND, OHIO  
 MANHATTAN RAYBESTOS COMPANY, CORINTH, KY.  
 MANSFIELD PHOTO ENGRAVING, MANSFIELD, OHIO  
 MARGMONT COMPANY, SAGO, ME.  
 MARLIN-ROCHELL COMPANY, PLAINVILLE, CONN.  
 MARQUARDT CORPORATION (THE), VAN NUYS, CALIF.  
 MARQUARDT CORPORATION (THE), UGDEM, UTAH  
 MARQUETTE METAL PRODUCTS CO., CLEVELAND, OHIO  
 MARSHALL SPACE FLIGHT CENTER, HUNTSVILLE, ALA.  
 MARTIN COMPANY, DENVER, COLO.  
 MARTIN COMPANY, ORLANDO, FLA.  
 MARTIN COMPANY, BALTIMORE, MD.

MARTIN COMPANY, WHEELING, ILL.  
MASSACHUSETTS INSTITUTE OF TECHNOLOGY, CAMBRIDGE,  
MASS.

MASSEY-FERGUSON INC., DETROIT, MICH.  
MASTER CHEMICAL CORPORATION, PERRYSBURG, OHIO  
MASTER MANUFACTURING CO. INC., HUTCHINSON, KAN.  
MATERIALS DEVELOPMENT INC., PROSPECT, KY.  
MATERIALS IN DESIGN ENGINEERING, NEW YORK, N.Y.  
MATERIALS TESTING LABORATORY, LOS ANGELES, CALIF.  
MAYNARD & COMPANY, INC., H.B., PITTSBURGH, PA.  
MCCULLOCH CORPORATION, LOS ANGELES, CALIF.  
MCDONNELL DOUGLAS CORP., LONG BEACH, CALIF.  
MCDONNELL DOUGLAS CORP., SANTA MONICA, CALIF.  
MCDONNELL DOUGLAS CORP., ST. LOUIS, MO.  
MCDONNELL DOUGLAS CORP., HUNTINGTON BEACH, CALIF.  
MCGRAW-EDISON COMPANY, PITTSBURGH, PA.  
MCGRAW-EDISON COMPANY, COLUMBUS, OHIO  
MCGRAW-EDISON COMPANY, SO. MILWAUKEE, WISC.  
MCGREGOR MANUFACTURING CORP., TROY, MICH.  
MCKINNEY INC., HARRIS D., PHILADELPHIA, PA.  
MCMELLON BROTHERS, INC., STRATFORD, CONN.  
MEAD CORPORATION, CINCINNATI, OHIO  
MEASUREGRAPH COMPANY, ST. LOUIS, MO.  
MECHANICAL SUPPLIES COMPANY, CINCINNATI, OHIO  
MELPAR INC., FALLS CHURCH, VA.  
MEMCOR INC., HUNTINGTON, IND.  
MENASCO MANUFACTURING COMPANY, BURBANK, CALIF.  
MENASCO MANUFACTURING COMPANY, FT. WORTH, TEX.  
MERCER ALLOYS CORPORATION, GREENVILLE, PA.  
MERCER MACHINE COMPANY, INDIANAPOLIS, IND.  
METAL FINISHING SERVICE, CHICAGO, ILL.  
METAL LUBRICANTS COMPANY, CHICAGO, ILL.  
METAL-MATION INC., SOUTH BEND, IND.  
METALORE, EL SEGUNDO, CALIF.  
METAL POWDER INDUSTRIES FEDERATION, NEW YORK, N.Y.  
METALWORKING MAGAZINE, BOSTON, MASS.  
METALWORKING NEWS, CINCINNATI, OHIO  
METCUT RESEARCH ASSOCIATES INC., CINCINNATI, OHIO  
METEM CORPORATION, HANOVER, N.J.  
MICHIGAN TECHNOLOGY UNIVERSITY, HOUGHTON, MICH.  
MICHIGAN TOOL COMPANY, DETROIT, MICH.  
MICHIGAN, UNIVERSITY OF, ANN ARBOR, MICH.  
MIDDLE COUNTRY CENTRAL SCHOOL DISTRICT 11,  
CENTEREACH, N.Y.  
MIDWEST RESEARCH INSTITUTE, KANSAS CITY, MO.  
MIDWEST TECHNICAL SERVICES, INC., CINCINNATI, OHIO  
MINIATURE PRECISION BEARINGS, INC., KEENE, N.H.  
MINNESOTA MINING & MANUFACTURING CO., ST. PAUL, MINN.  
MODERN MACHINE SHOP, CINCINNATI, OHIO  
MOHAWK TOOLS, INC., MONTPELIER, OHIO  
MONSANTO RESEARCH CORPORATION, DAYTON, OHIO  
MONSANTO RESEARCH CORPORATION, MIAMISBURG, OHIO  
MONSANTO RESEARCH CORPORATION, HARTFORD, CONN.  
MONTGOMERY CO., H. A., DETROIT, MICH.  
MOOG, INC., EAST AURORA, N.Y.  
MOREHEAD STATE UNIVERSITY, MOREHEAD, KY.  
MONFORM TOOL COMPANY, CINCINNATI, OHIO  
MORGEN DESIGN, INC., CINCINNATI, OHIO  
MORRIS & COMPANY, E. K., CINCINNATI, OHIO  
MORRIS MACHINE CO. INC., INDIANAPOLIS, IND.  
MORSE TWIST DRILL & MACHINE CO., CHICAGO, ILL.  
MORWEAR TOOLS INC., CINCINNATI, OHIO  
MOSLER LOCK COMPANY, MILFORD, OHIO  
MOTOROLA INC., SCOTTSDALE, ARIZ.  
MUSKEGON TOOL INDUSTRIES INC., MUSKEGON, MICH.

NASA, SCIENTIFIC & TECHNOLOGY INFORMATION FACILITY,  
BETHESDA, MD.  
NASA, LANGLEY RESEARCH CENTER, HAMPTON, VA.  
NASA, LEWIS RESEARCH CENTER, CLEVELAND, OHIO  
NATIONAL BERYLLIA CORPORATION, HASKELL, N.J.  
NATIONAL BUREAU OF STANDARDS, BOULDER, COLO.

NATIONAL CASH REGISTER COMPANY, DAYTON, OHIO  
NATIONAL FORGE COMPANY, IRVINE, WARREN COUNTY, PA.  
NATIONAL LEAD COMPANY OF OHIO, CINCINNATI, OHIO  
NATIONAL LEAD COMPANY OF OHIO, FERNALD, OHIO  
NATIONAL SCREW MACHINE PRODUCTS ASSOCIATION,  
CLEVELAND, OHIO

NATIONAL WATER LIFT COMPANY, KALAMAZOO, MICH.  
NAVAL AIR ENGINEERING CENTER, PHILADELPHIA, PA.  
NAVAL AIR REWORK FACILITIES, SAN DIEGO, CALIF.  
NELCO CUTTER COMPANY, MANCHESTER, CONN.  
NEUMAN & COMPANY, H., SKOKIE, ILL.  
NEVILL, C. R., INDIANAPOLIS, IND.  
NEW BRITAIN MACHINE CO. (THE), NEW BRITAIN, CONN.  
NEW ENGLAND METALLURGICAL CORPORATION, S. BOSTON,  
MASS.

NEW ENGLAND RESEARCH APPLICATION CENTER, STORRS,  
CONN.

NEW YORK STATE UNIVERSITY OF BINGHAMTON,  
BINGHAMTON, N.Y.

NOBLE INC., NORMAN, CLEVELAND, OHIO

NORDEN COMPANY, NORWALK, CONN.

NORTH AMERICAN ROCKWELL CORP., ANAHEIM, CALIF.

NORTH AMERICAN ROCKWELL CORP., CANOGA PARK, CALIF.

NORTH AMERICAN ROCKWELL CORP., EL SEGUNDO, CALIF.

NORTH AMERICAN ROCKWELL CORP., INGLEWOOD, CALIF.

NORTH AMERICAN ROCKWELL CORP., LOS ANGELES, CALIF.

NORTH AMERICAN ROCKWELL CORP., NEOSHO, MO.

NORTH AMERICAN ROCKWELL CORP., COLUMBUS, OHIO

NORTH AMERICAN ROCKWELL CORP., TULSA, OKLA.

NORTH CAROLINA STATE UNIVERSITY, RALEIGH, N.C.

NORTH HARTFORD HIGH SCHOOL, PYLESVILLE, MD.

NORTHEASTERN UNIVERSITY, BOSTON, MASS.

NORTHROP NORAIR, HAWTHORNE, CALIF.

NORTHROP VENTURA, NEWBURY PARK, CALIF.

NORTON COMPANY, WORCESTER, MASS.

NRC EQUIPMENT CORPORATION, NEWTON, MASS.

NUCLEAR METALS, INC., WEST CONCORD, MASS.

NUMERICAL CONTROL & COMPUTER SERVICES, CLEVELAND  
OHIO

NU TEC ENGINEERING CORPORATION, WARREN, MICH.

NU-TOOL SAW SERVICE, INC., DETROIT, MICH.

OK TOOL COMPANY, MILFORD, N.H.

OAKES CORPORATION, E. T., LONG ISLAND, N.Y.

OBERG MANUFACTURING COMPANY, INC., FREEPORT, PA.

OHIO STATE UNIVERSITY (THE), COLUMBUS, OHIO

OKLAHOMA STATE UNIVERSITY, STILLWATER, OKLA.

OLIN DIXON CORPORATION, COFFEYVILLE, KAN.

OLIVER MACHINERY COMPANY, GRAND RAPIDS, MICH.

ONTARIO CORPORATION, MUNCIE, IND.

OREGON TECHNICAL INSTITUTE, KLAMATH FALLS, ORE.

OTIS ELEVATOR COMPANY, YONKERS, N.Y.

OWENS-ILLINOIS, INC., COLUMBUS, OHIO

PACIFIC SCIENTIFIC COMPANY, ANAHEIM, CALIF.

PACKER CONSULTING ASSOCIATES, NAPERVILLE, ILL.

PANDA PRODUCTS, CINCINNATI, OHIO

PEABODY INDUSTRIES, PEABODY, MASS.

PECK, PAUL H., BROCKTON, MASS.

PENN NUCLEAR CORPORATION, PENN, PA.

PENNSYLVANIA STATE UNIVERSITY, UNIVERSITY PARK,  
PA.

PENTA TECHNICAL COLLEGE, PERRYSBURG, OHIO

PESCO PRODUCTS, BEDFORD, OHIO

PHELPS-DODGE-COPPER PRODUCTS CORP., ELIZABETH,  
N.J.

PHILADELPHIA NAVAL SHIPYARD, PHILADELPHIA, PA.

PHILCO CORPORATION, LAWDALE, CALIF..

PHILCO CORPORATION, NEWPORT BEACH, CALIF.

PICATINNY ARSENAL, DOVER, N.J.

PIPE MACHINERY COMPANY, CLEVELAND, OHIO

PITTSBURGH PLATE GLASS CO., PITTSBURGH, PA.

PLANET PRODUCTS CORPORATION, CINCINNATI, OHIO  
 POINT PARK COLLEGE, PITTSBURGH, PA.  
 POLYMET CORPORATION, CINCINNATI, OHIO  
 PRATT & WHITNEY AIRCRAFT, EAST HARTFORD, CONN.  
 PRATT & WHITNEY AIRCRAFT, NORTH HAVEN, CONN.  
 PRATT & WHITNEY AIRCRAFT, WEST PALM BEACH, FLA.  
 PRATT & WHITNEY CORPORATION, W. HARTFORD, CONN.  
 PRATT & WHITNEY CORPORATION, CUDAHY, CALIF.  
 PRECISION CASTPARTS CORP., PORTLAND, ORE.  
 PRECISION MACHINE & TOOL, INC., VANDALIA, OHIO  
 PRECISION MECHANICS INC., CINCINNATI, OHIO  
 PRESTOLITE COMPANY (THE), DECATUR, ALA.  
 PRISOCK ASSOCIATES, JOHN, CINCINNATI, OHIO  
 PROCTER & GAMBLE COMPANY, CINCINNATI, OHIO  
 PRUYNE COMPANY, SAN DIEGO, CALIF.  
 PURDUE UNIVERSITY, WEST LAFAYETTE, IND.

RGF CORPORATION, ELWOOD, IND.  
 RADIO CORPORATION OF AMERICA, CAMDEN, N.J.  
 RADIO CORPORATION OF AMERICA, PRINCETON, N.J.  
 RADIO CORPORATION OF AMERICA, LANCASTER, PA.  
 RADIO ENGINEERING LABORATORIES, LONG ISLAND, N.Y.  
 RAYTHEON COMPANY, WALTHAM, MASS.  
 RAYTHEON COMPANY, WYLAND, MASS.  
 RAYTHEON COMPANY, BRISTOL, TENN.  
 REACTIVE METALS, INC., NILES, OHIO  
 REDSTONE ARSENAL, U.S. ARMY MISSILE COMMAND,  
 REDSTONE ARSENAL, ALA.  
 REGENTS OF THE UNIVERSITY SYSTEM OF GEORGIA,  
 ATLANTA, GA.  
 RELIANCE ELECTRIC COMPANY, ASHTABULA, OHIO  
 REMINGTON ARMS COMPANY, INC., BRIDGEPORT, CONN.  
 REPUBLIC STEEL CORPORATION, CLEVELAND, OHIO  
 RESOURCES DEVELOPMENT CORPORATION, EAST LANSING,  
 MICH.  
 REX CHAINBELT, INC., DOWNERS GROVE, ILL.  
 REYNOLDS METALS COMPANY, RICHMOND, VA.  
 RIDINGS, JAMES A., PITTSBURG, KAN.  
 ROCK ISLAND ARSENAL, ROCK ISLAND, ILL.  
 ROHR CORPORATION, CHULA VISTA, CALIF.  
 ROLLWAY BEARING COMPANY, SYRACUSE, N.Y.  
 ROMA CORPORATION, INDIANAPOLIS, IND.  
 ROOTS-CONNERSVILLE, BLOWER DIV., CONNERSVILLE, IND.  
 RUST-LICK INC., BOSTON, MASS.  
 RYERSON & SON, INC., JOSEPH T., CHICAGO, ILL.

SKF INDUSTRIES, TIMONIUM, MD.  
 S&S MACHINERY COMPANY, BROOKLYN, N.Y.  
 SAE STEELS, INC., HUDSON, OHIO  
 SAN JOSE STATE COLLEGE, SAN JOSE, CALIF.  
 SANDERS ASSOCIATES, NASHUA, N.H.  
 SANDIA CORPORATION, ALBUQUERQUE, N.M.  
 SATEC CORPORATION, GROVE CITY, PA.  
 SAUNDERS & CO. INC., ALEXANDER, COLD SPRING, N.Y.  
 SCHELLENS TRUE CORPORATION, IVORYTON, CONN.  
 SEATTLE UNIVERSITY, SEATTLE, WASH.  
 SEIFREATH-ELSTAD MACHINERY CO., CINCINNATI, OHIO  
 SETCO INDUSTRIES INC., CINCINNATI, OHIO  
 SEYBOLD COMPANY, CINCINNATI, OHIO  
 SHEAFFER PEN COMPANY, W. A., FT. MADISON, IOWA  
 SHEFFER CORPORATION (THE), CINCINNATI, OHIO  
 SHEFFIELD CORPORATION (THE), DAYTON, OHIO  
 SHWAYDER CHEMICAL METALLURGY CORP., DETROIT, MICH.  
 SIKORSKY AIRCRAFT, STRATFORD, CONN.  
 SILTRONICS INC., OAKMONT, PA.  
 SINCLAIR REFINING COMPANY, CHICAGO, ILL.  
 SINCLAIR REFINING COMPANY, COLUMBUS, OHIO  
 SMALL BUSINESS ADMINISTRATION, CHICAGO, ILL.  
 SNAP-ON-TOOLS COMPANY, KENOSHA, WISC.  
 SONNET TOOL & MFG. CO., HAWTHORNE, CALIF.  
 SOUTH CHESTER CORPORATION, LESTER, PA.  
 SOUTH SHORE TOOL & DEVELOPMENT INC., MENTOR, OHIO  
 SOUTHERN AUTOMATICS INC., CINCINNATI, OHIO

SOUTHERN ILLINOIS UNIVERSITY, CARBONDALE, ILL.  
 SOUTHWEST RESEARCH INSTITUTE, SAN ANTONIO, TEX.  
 SPECIAL MACHINE COMPANY, ROCKFORD, ILL.  
 SPERRY RAND CORPORATION, CLEARWATER, FLA.  
 SPERRY RAND CORPORATION, DETROIT, MICH.  
 SPERRY RAND CORPORATION, JACKSON, MISS.  
 SPERRY RAND CORPORATION, TROY, MICH.  
 SPERRY RAND CORPORATION, BRISTOL, TENN.  
 SPERRY RAND CORPORATION, SALT LAKE CITY, UTAH  
 SPINDLETOP RESEARCH, LEXINGTON, KY.  
 SPRINGFIELD ARMORY, SPRINGFIELD, MASS.  
 ST. JOSEPH LEAD COMPANY, MONACA, PA.  
 STANDARD OIL COMPANY-OHIO (THE), CLEVELAND, OHIO  
 STANDARD PRESSED STEEL CO., JENKINTOWN, PA.  
 STARK INDUSTRIAL SUPPLY COMPANY, CANTON, OHIO  
 STATHAM INSTRUMENTS, OXNARD CALIF.  
 STEEL MAGAZINE, CLEVELAND, OHIO  
 STERLING FAUCET COMPANY, MORGANTOWN, W. VA.  
 STERLING GRINDING WHEEL CO., TIFFIN, OHIO  
 STERLING INSTRUMENT, MINEOLA, N.Y.  
 STEVENS INSTITUTE OF TECHNOLOGY, HOBOKEN, N.J.  
 STRASMAN MACHINERY CORPORATION, LONG BEACH, CALIF.  
 STUART OIL CO., LTD., D. A., CHICAGO, ILL.  
 STUDEBAKER CORPORATION, DUNBAR, W. VA.  
 STYRE/PAK, NEWTON, IOWA  
 SUN OIL COMPANY, CINCINNATI, OHIO  
 SUN OIL COMPANY, MARCUS HOOK, PA.  
 SUN SHIPBUILDING & DRY DOCK CO., CHESTER, PA.  
 SUNDSTRAND CORPORATION, SUNDSTRAND AVIATION,  
 ROCKFORD, ILL.  
 SUNDSTRAND CORPORATION, SUNDSTRAND MACHINE TOOL CO.,  
 BELVIDERE, ILL.  
 SYLVANIA ELECTRIC PRODUCTS, INC., SALEM, MASS.  
 SYLVESTRE SCREW COMPANY, PROVIDENCE, R. I.  
 SYSTEMS RESEARCH LABS., DAYTON, OHIO

TRW INC., CLEVELAND, OHIO  
 TRW INC., DANVILLE, PA.  
 TRW INC., LEBANON, TENN.  
 TAFT ENGINEERING CENTER, CINCINNATI, OHIO  
 TAYLOR FORGE INC., CHICAGO, ILL.  
 TECHNICAL CONSULTANTS INC., HUNTINGTON, W. VA.  
 TECHNICAL EQUIPMENT SALES CO., CINCINNATI, OHIO  
 TECHNICAL & TRADE TRAINING CENTER, WESTBURY, N.Y.  
 TECUMSEH PRODUCTS COMPANY, ANN ARBOR, MICH.  
 TELEDYNE INC, WAH CHANG, GLEN COVE, N.Y.  
 TELEDYNE INC., ALLVAC METALS, MONROE, N.C.  
 TELEDYNE INC., FIRTH STERLING, PITTSBURGH, PA.  
 TELEDYNE INC., VASCO, LATROBE, PA.  
 TELEDYNE INC., AUTOMATED SPECIALTIES,  
 CHARLOTTESVILLE, VA.  
 TELEFLEX INC., NORTH WALES, PA.  
 TELETYPE CORPORATION, SKOKIE, ILL.  
 TENNESSEE, UNIVERSITY OF, KNOXVILLE, TENN.  
 TEXACO INC., BEACON, N.Y.  
 TEXACO INC., CINCINNATI, OHIO  
 TEXAS INSTRUMENTS INC., DALLAS, TEX.  
 TEXAS, UNIVERSITY OF, AUSTIN, TEX.  
 THERM INC., ITHACA, N.Y.  
 THIOKOL CHEMICAL CORP., DENVER, N.J.  
 THOMPSON COMPANY, JOHN I., WASHINGTON, D.C.  
 TIMKEN ROLLER BEARING COMPANY, CANTON, OHIO  
 TINKER AIR FORCE BASE, OKLAHOMA CITY, OKLA.  
 TIPP MACHINE & TOOL INC., TIPP CITY, OHIO  
 TIPPETT INCORPORATED, CHICOPEE FALLS, MASS.  
 TITANIUM METALS CORPORATION OF AMERICA,  
 NEW YORK, N.Y.  
 TITANIUM METALS CORPORATION OF AMERICA,  
 TORONTO, OHIO  
 TOOL SALES & SERVICE, CINCINNATI, OHIO  
 TOOL STEEL GEAR & PINION CO. (THE), CINCINNATI,  
 OHIO

TOULON HIGH SCHOOL, TOULON, ILL.  
 TOWNSEND COMPANY, SANTA ANA, CALIF.  
 TRAUB STROHM CORPORATION, PLAINVIEW, N.Y.  
 TRI INDUSTRIES INC., TERRE HAUTE, IND.  
 TRI-D CORPORATION, PLAINVILLE, CONN.  
 TRU-CUT MACHINE CORPORATION, CINCINNATI, OHIO  
 TYCO LABORATORIES, WALTHAM, MASS.  
 TYLER CORPORATION, BENSON, MINN.

UTD CORPORATION, ATHOL, MASS.  
 U.S. ARMY, PRODUCTION ENGINEERING DIVISION,  
 FT. BELVOIR, VA.  
 U.S. ARMY, EDGEWOOD ARSENAL, EDGEWOOD ARSENAL, MD.  
 U.S. ARMY, PRODUCTION EQUIPMENT AGENCY,  
 ROCK ISLAND, ILL.  
 U.S. ARMY, WEAPONS COMMAND, ROCK ISLAND, ILL.  
 U.S. ATOMIC ENERGY COMMISSION, WASHINGTON, D.C.  
 U.S. BAIRD CORPORATION, STRATFORD, CONN.  
 U.S. DEFENSE SUPPLY AGENCY, CINCINNATI, OHIO  
 U.S. DEPARTMENT OF DEFENSE, N. ARLINGTON, VA.  
 U.S. DEPARTMENT OF THE INTERIOR, ROLLA, MO.  
 U.S. DEPARTMENT OF JUSTICE, WASHINGTON, D.C.  
 U.S. MARINE CORPS., CHERRY POINT, N.C.  
 U.S. NAVAL AVIONICS FACILITY, DEPARTMENT OF NAVY,  
 INDIANAPOLIS, IND.  
 U.S. MISSILE CENTER, MUGU, CALIF.  
 U.S. NAVAL ORDNANCE LAB., WHITE OAK, MD.  
 U.S. NAVAL ORDNANCE TEST STATION, CHINA LAKE,  
 CALIF.  
 U.S. NAVAL POST GRADUATE SCHOOL, MONTEREY, CALIF.  
 U.S. NAVAL UNDERWATER ORDNANCE STATION, NEWPORT,  
 R.I.  
 U.S. STEEL CORPORATION, MONROEVILLE, PA.  
 UNION CARBIDE CORPORATION, INDIANAPOLIS, IND.  
 UNION CARBIDE CORPORATION, KOKOMO, IND.  
 UNION CARBIDE CORPORATION, PADUCAH, KY.  
 UNION CARBIDE CORPORATION, OAK RIDGE NATIONAL  
 LAB, OAK RIDGE, TENN.  
 UNION CARBIDE CORPORATION, Y12 PLANT, OAK RIDGE,  
 TENN.  
 UNITED AIRCRAFT CORPORATE SYSTEMS CENTER,  
 FARMINGTON, CONN.  
 UNITED AIR LINES, SAN FRANCISCO, CALIF.  
 UNITED STATES BORAX & CHEMICAL CORP., NEW YORK, N.Y.  
 UNITED STATES LIAISON OFFICE, APO, N.Y.  
 UNITED STATES TIME CORPORATION, WATERBURY, CONN.  
 UNITED TECHNOLOGY CENTER, SUNNYVALE, CALIF.  
 UNIVAC, ROSEVILLE, MINN.  
 UNIVERSAL-CYCLOPS SPECIALTY STEEL, BRIDGEVILLE, PA.  
 UNIVERSAL TECHNOLOGY CORP., DAYTON, OHIO  
 UNIVERSAL VALVE COMPANY, INC., ELIZABETH, N.J.  
 UTAH, UNIVERSITY OF, SALT LAKE CITY, UTAH  
 UTAH STATE UNIVERSITY, LOGAN, UTAH

V.I. JEWELRY MANUFACTURING CORP., NEW YORK, N.Y.  
 VALERON CORPORATION (THE), LOS ANGELES, CALIF.  
 VALERON CORPORATION (THE), INDIANAPOLIS, IND.  
 VALERON CORPORATION (THE), DAYTON, OHIO  
 VALUE PROGRAM FOR INDUSTRY, SCHENECTADY, N.Y.  
 VAN STRAATEN CHEMICAL COMPANY, CHICAGO, ILL.  
 VARO INC., SANTA BARBARA, CALIF.  
 VEEDER-ROOT INC., ALTOONA, PA.  
 VERMONT AMERICAN CORPORATION, LOUISVILLE, KY.  
 VIKING FORGE & STEEL COMPANY, ALBANY, CALIF.

VINCO CORPORATION, DETROIT, MICH.  
 VIRGINIA POLYTECHNIC INSTITUTE, BLACKSBURG, VA.  
 VITRO CORPORATION OF AMERICA, WEST ORANGE, N.J.  
 VOGT MACHINE CO. INC., HENRY, LOUISVILLE, KY.  
 VR/WESSON COMPANY, CINCINNATI, OHIO

WALKER COMPANY, O.S., WORCESTER, MASS.  
 WALKER GRINDING COMPANY, SANTA BARBARA, CALIF.  
 WALMET CORPORATION (THE), PLEASANT RIDGE, MICH.  
 WALMET CORPORATION (THE), SUMMITT, N.J.  
 WALTCO ENGINEERING COMPANY, GARDENA, CALIF.  
 WARNER-SWASEY COMPANY (THE), CLEVELAND, OHIO  
 WARNER-SWASEY COMPANY (THE), LAHR DIVISION,  
 CLEVELAND, OHIO  
 WARREN PUMPS, INC., WARREN, MASS.  
 WATERTOWN ARSENAL, WATERTOWN, MASS.  
 WATERVLIET ARSENAL, WATERVLIET, N.Y.  
 WAYNE STATE UNIVERSITY, DETROIT, MICH.  
 WEATHERHEAD COMPANY (THE), DAYTON, OHIO  
 WEBCO MACHINE PRODUCTS, INC., CLEVELAND, OHIO  
 WEINMAN PUMP MANUFACTURING CO. (THE), COLUMBUS, OHIO  
 WEST MILTON PRECISION TOOL CO., VANDALIA, OHIO  
 WEST VIRGINIA, STATE OF, DEPARTMENT OF COMMERCE,  
 CHARLESTON, W. VA.  
 WESTERN ELECTRIC COMPANY, INC., OMAHA, NEB.  
 WESTERN ELECTRIC COMPANY, INC., GREENSBORO, N.C.  
 WESTERN ELECTRIC COMPANY, INC., PRINCETON, N.J.  
 WESTERN ELECTRIC COMPANY, INC., NEW YORK, N.Y.  
 WESTERN GEAR CORPORATION, EVERETT, WASH.  
 WESTERN RESERVE UNIVERSITY, CLEVELAND, OHIO  
 WESTINGHOUSE AIR BRAKE COMPANY, PEORIA, ILL.  
 WESTINGHOUSE ELECTRIC CORP., SUNNYVALE, CALIF.  
 WESTINGHOUSE ELECTRIC CORP., BUFFALO, N.Y.  
 WESTINGHOUSE ELECTRIC CORP., BLAIRSVILLE, PA.  
 WESTINGHOUSE ELECTRIC CORP., HOMESWOOD, PA.  
 WESTINGHOUSE ELECTRIC CORP., PHILADELPHIA, PA.  
 WESTINGHOUSE ELECTRIC CORP., PITTSBURGH, PA.  
 WHEELABRATOR CORPORATION, MISHAWAKA, INC.  
 WHITE COUNTY MACHINE SHOP, MONTICELLO, INC.  
 WHITIN MACHINE WORKS, WHITINSVILLE, MASS.  
 WHITTAKER CORPORATION, LA MESA, CALIF.  
 WHITTAKER CORPORATION, WEST CONCORD, MASS.  
 WILLIAMS RESEARCH & ENGINEERING CO., WALLED LAKE,  
 MICH.  
 WISCONSIN, UNIVERSITY, MADISON, WISC.  
 WISCONSIN STATE UNIVERSITY, PLATTEVILLE, WISC.  
 WITHROW COMPANY, ARTHUR C., LOS ANGELES, CALIF.  
 WOLVERINE BRASS WORKS, GRAND RAPIDS, MICH.  
 WORLD TOOL & ENGINEERING CO., MINNEAPOLIS, MINN.  
 WRIGHT-PATTERSON AIR FORCE BASE, MANUFACTURING  
 TECHNOLOGY DIVISION, WRIGHT-PATTERSON AFB,  
 OHIO  
 WRIGHT-PATTERSON AIR FORCE BASE FOREIGN DISCLOSURE  
 OFFICE, WRIGHT-PATTERSON AFB, OHIO  
 WRIGHT-PATTERSON AIR FORCE BASE FOREIGN TECHNOLOGY  
 OFFICE, WRIGHT-PATTERSON AFB, OHIO  
 WYMAN-GORDON COMPANY, NORTH GRAFTON, MASS.  
 WYMAN-GORDON COMPANY, WORCESTER, MASS.

XEROX CORPORATION, ROCHESTER, N.Y.

ZENITH MANUFACTURING COMPANY, OAK PARK, MICH.  
 ZIMNEY CORPORATION, MONROVIA, CALIF.

# NEW COMPANIES & AGENCIES SUBMITTING INQUIRIES TO AFMDC

FEBRUARY 1, 1968 - SEPTEMBER 30, 1968

ATI INDUSTRIES, ESCONDIDO, CALIF.  
 ACCURATE DIAMOND TOOL CORP., HACKENSACK, N.J.  
 ADAPTO, GOODYEAR, ARIZ.  
 ALCO PRODUCTS, INC., SCHENECTADY, N.Y.  
 ALEXANDER & ASSOCIATES, CINCINNATI, OHIO  
 AMACOIL TOOL DIVISION, CHICAGO, ILL.  
 AMBERG & USLER, INC., EAST ORANGE, N.J.  
 AMERICAN BOSCH ARMA CORP., GARDEN CITY, N.Y.  
 AMERICAN BUSINESS DEVELOPMENT, LOS ANGELES, CALIF.  
 AMERICAN CAN COMPANY, SAN FRANCISCO, CALIF.  
 AMERICAN CAN COMPANY, GENEVA, N.Y.  
 AMERICAN IRON AND STEEL INST., NEW YORK, N.Y.  
 AMERICAN OIL COMPANY, CHICAGO, ILL.  
 AMERICAN OIL COMPANY, WHITING, IND.  
 AMERICAN TOOL COMPANY, KALAZAMOO, MICH.  
 AMTEL, INC., PEABODY, MASS.  
 ANZON COMPANY, INC., EL MONTE, CALIF.  
 APPLIED OCEANICS, LOS ANGELES, CALIF.  
 ARIZONA STATE UNIVERSITY, TEMPE, ARIZ.  
 ARNO ADHESIVE TAPE, INC., MICHIGAN CITY, IND.  
 ASTRO MET ASSOCIATES, INC., CINCINNATI, OHIO  
 ASTRO TECH, INC., MINNEAPOLIS, MINN.  
 ATLAS PORTABLE EQUIPMENT CO., OAK PARK, MICH.  
 AUTOMATION INDUSTRIES, INC., STERLING, VA.  
 AVCO CORPORATION, WESTBORO, MASS.  
 AVIATION WEEK & SPACE TECHNOLOGY, NEW YORK, N.Y.

BALL BROS. RESEARCH CORP., BOULDER, COLO.  
 BARBER-COLMAN COMPANY, ROCKFORD, ILL.  
 BARRY-WEHMILLER COMPANY, ST. LOUIS, MO.  
 BATH IRON WORKS, BATH, ME.  
 BAY SWISS MFG. CO., INC., EL SEGUNDO, CALIF.  
 BENDIX CORP., GREENFIELD, MASS.  
 BOOZ ALLEN APPLIED RESEARCH, INC., INDEPENDENCE, OHIO  
 BORG-WARNER CORPORATION, DES PLAINES, ILL.  
 BRIDGEPORT BRASS COMPANY, INDIANAPOLIS, IND.

CADILLAC GAGE COMPANY, COSTA MESA, CALIF.  
 CALIFORNIA, UNIVERSITY OF, LIVERMORE, CALIF.  
 CARLTON MACHINE TOOL COMPANY, CINCINNATI, OHIO  
 CHEMCUT CORPORATION, STATE COLLEGE, PA.  
 CHICAGO PNEUMATIC TOOL CO., UTICA, N.Y.  
 CHROMALLOY AMERICAN CORP., WEST NYACK, N.Y.  
 CINCINNATI MILLING MACHINE COMPANY (THE),  
 WILMINGTON, OHIO  
 CLECO PNEUMATIC, CINCINNATI, OHIO  
 CLIMAX MOLYBDENUM CO., NEW YORK, N.Y.  
 COMMERCIAL SCREW PRODUCTS, INC., CLEVELAND, OHIO  
 CONAX CORPORATION, BUFFALO, N.Y.  
 CONTROL MECHANISMS INC., PHILADELPHIA, PA.  
 COPAT CORPORATION, BEECH GROVE, IND.  
 CORDELL ASSOCIATES, LOS ANGELES, CALIF.  
 COX MANUFACTURING CO., INC., SAN ANTONIO, TEX.  
 CYCLOPS CORPORATION, PITTSBURGH, PA.  
 CRANE COMPANY, CHICAGO, ILL.

DEA PRODUCTS, TEMPE, ARIZ.  
 DANA CORPORATION, RICHMOND, IND.  
 DANA CORPORATION, TOLEDO, OHIO  
 DANVILLE METAL STAMPING, DANVILLE, ILL.  
 DE LAVAL TURBINE, INC., TRENTON, N.J.  
 DENVER, UNIVERSITY OF, DENVER, COLO.  
 DEUTSCH COMPANY, BANNING, CALIF.  
 DO ALL CLEVELAND COMPANY, CINCINNATI, OHIO  
 DUPONT DENEMOURS & CO., E.I., POMPTON LAKE, N.J.  
 DURIRON COMPANY, INC., DAYTON, OHIO  
 DYNA-EMPIRE, INC., LONG ISLAND, N.Y.  
 DYNAMICS CORP. OF AMERICA, GARDEN CITY, N.Y.

EAM INC., SKIPPAK, PA.  
 EAGLE TOOL & MACHINE COMPANY, SPRINGFIELD, OHIO  
 ELECTRO-METHODS, INC., SOUTH WINDSOR, CONN.  
 ELECTROFILM, INC., NORTH HOLLYWOOD, CALIF.  
 EMBOSOGRAPH DISPLAY MFG., CO., CHICAGO, ILL.  
 ENGIS EQUIPMENT CO., MORTON GROVE, ILL.

FMC CORPORATION, SANTA CLARA, CALIF.  
 FEDERAL MOGUL CORP., DETROIT, MICH.  
 FIBEREX COMPANY, CLEVELAND, OHIO  
 FORTNER ENGINEERING & MFG., INC., GLENDALE, CALIF.  
 FRECON ENGINEERING, CINCINNATI, OHIO

GEARCRAFT, INC., HAZEL PARK, MICH.  
 GENERAL DYNAMICS CORP., POMONA, CALIF.  
 GENERAL ELECTRIC COMPANY, CHICAGO, ILL.  
 GENERAL ELECTRIC COMPANY, W. BURLINGTON, IOWA  
 GENERAL ELECTRIC COMPANY, OAK PARK, MICH.  
 GENERAL ELECTRIC COMPANY, MILWAUKEE, WISC.  
 GENERAL MANUFACTURING CORP., LODI, N.J.  
 GENERAL MOTORS CORPORATION, LANSING, MICH.  
 GRAND VALLEY STATE COLLEGE, ALLENDALE, MICH.  
 GRUMMAN AIRCRAFT ENGRG., GLENARN, MD.  
 GULF GENERAL ATOMIC INC., SAN DIEGO, CALIF.

HARNISCHFEGGER, MILWAUKEE, WISC.  
 HARRELL HOLMES MARKETING, CINCINNATI, OHIO  
 HARRISON MANUFACTURING CO., TEMPE, ARIZ.  
 HAYES-ALBION CORPORATION, HILLSDALE, MICH.  
 HAYES, MAX S. VOCATIONAL HIGH SCHOOL,  
 CLEVELAND, OHIO  
 HEWLETT-PACKARD CO., PALO ALTO, CALIF.  
 HITTMAN ASSOCIATES, INC., COLUMBIA, MD.  
 HONEYWELL, INC., HOPKINS, MINN.  
 HUYCK METALS COMPANY, MILFORD, CONN.

ITT-GILFILLAN, VAN NUYS, CALIF.  
 ILLINOIS TOOL WORKS, INC., ELGIN, ILL.  
 INDUSTRIAL PRESS, INC., NEW YORK, N.Y.  
 INDUSTRIAL TOOL & MACHINE CO., GEORGIATOWN, R.I.  
 INDUSTRIAL TECTONICS, INC., COMPTON, CALIF.  
 INTERNATIONAL HARVESTER COMPANY, SAN DIEGO, CALIF.  
 ITEK CORPORATION, LEXINGTON, MASS.

JACKUP BOAT BUILDERS, INC., BRAITHWAITE, LA.  
 JANITROL AERO, COLUMBUS, OHIO  
 JOHNSON, BILL SUPPLY CO., PHOENIX, ARIZ.  
 JOINT VOCATIONAL SCHOOL, SPRINGFIELD, OHIO  
 JOMICO METAL FABRICATION, ST. LOUIS, MO.

KAMINGA MANUFACTURING CO., GRAND RAPIDS, MICH.  
 KEMPER INSURANCE CO., NEW YORK, N.Y.  
 KNOLLS ATOMIC POWER LAB., NISKAYUNA, N.Y.

LDR TOOL COMPANY, PROVIDENCE, R.I.  
 LA SALLE STEEL COMPANY, CHICAGO, ILL.  
 LITWIN COMPANY, CINCINNATI, OHIO

MACHINERY, WHEATON, ILL.  
 MACHINERY SALES COMPANY, LOS ANGELES, CALIF.  
 MCCLELLAN AIR FORCE BASE, SACRAMENTO, CALIF.  
 MECHANICAL SPECIALTIES, INC., LOS ANGELES, CALIF.  
 MEDICO INDUSTRIES, INC., WILKES BARRE, PA.  
 MICHIGAN ABRASIVE COMPANY, DETROIT, MICH.  
 MICHIGAN TECHNOLOGY UNIVERSITY, HOUGHTON, MICH.  
 MICHIGAN STATE UNIVERSITY, EAST LANSING, MICH.  
 MICHIGAN UNIVERSITY, CENTRAL, MT. PLEASANT, MICH.  
 MICHIGAN UNIVERSITY, EASTERN, YPSILANTI, MICH.  
 MICHIGAN UNIVERSITY, NORTHERN, MARQUETTE, MICH.  
 MIDDLETOWN HIGH SCHOOL, MIDDLETOWN, OHIO



MILLER, L.C. COMPANY, MONTEREY PARK, CALIF.  
 MILLERS FALLS COMPANY, CINCINNATI, OHIO  
 MILWAUKEE GEAR COMPANY, MILWAUKEE, WISC.  
 MONITOR BOXART CORP., FARMINGDALE, L.I., N.Y.  
 MONTGOMERY ELEVATOR COMPANY, MOLINE, ILL.  
 MOTION INDICATING DEVICES, INC., BUFFALO, N.Y.

NASA, HUNTSVILLE, ALA.  
 NASA, MOFFETT FIELD, CALIF.  
 NAVAL RESEARCH OFFICE OF, WASHINGTON, D.C.  
 NEW HAMPSHIRE BALL BEARINGS, INC., PETERBOROUGH, N.H.  
 NOLTE SCREW MACHINE, CINCINNATI, OHIO  
 NORTHEAST CUTTER SERVICE CORP., FARMINGDALE, N.Y.  
 NORTHMONT SCHOOL, CLAYTON, OHIO

OHIO COLLEGE OF APPLIED SCIENCE, CINCINNATI, OHIO  
 OHIO SCREW PRODUCTS, INC., ELYRIA, OHIO  
 ONSRUD MACHINE WORKS, NILES, ILL.  
 OWENS-ILLINOIS, TOLEDO, OHIO

P.E. DEVELOPMENT COMPANY, CINCINNATI, OHIO  
 PAYER, E.L. COMPANY, WENONAH, N.J.  
 PERKIN-ELMER CORP., DANBURY, CONN.  
 PIFER INDUSTRIES, INC., DURHAM, N.C.  
 PIONEER ASTRO INDUSTRIES, INC., HARWOOD HEIGHTS, ILL.  
 PIONEER BROACH COMPANY, LOS ANGELES, CALIF.  
 PLASTIC MOLDINGS CORP., CINCINNATI, OHIO  
 PUBLIC HEALTH SERVICE, BETHESDA, MD.  
 PUREX CORPORATION LTD., ANAHEIM, CALIF.

QUAKER CHEMICAL CORPORATION, CONSHOHOCKEN, PA.

RADIO CORPORATION OF AMERICA, INDIANAPOLIS, IND.  
 REEDER & KLINE MACHINE CO., INC., CARMEL, IND.  
 REX CHAINBELT, INC., MILWAUKEE, WISC.  
 RHODE ISLAND, UNIVERSITY OF, KINGSTON, R.I.  
 ROYAL OAK TOOL COMPANY, ROYAL OAK, MICH.  
 RYAN AERONAUTICAL COMPANY, SAN DIEGO, CALIF.  
 RYERSON & SON, JOSEPH T., CINCINNATI, OHIO

SCM CORPORATION, ORANGEBURG, S. C.  
 S & R TOOL CORPORATION, DAYTON, OHIO  
 SAGINAW VALLEY COLLEGE, UNIV. CENTER, MICH.  
 SANDERS NUCLEAR CORP., NASHUA, N.H.  
 SAN FRANCISCO CITY COLLEGE, SAN FRANCISCO, CALIF.  
 SCHUTTE AND KOERTING COMPANY, BUCKS COUNTY, PA.  
 SENCO PRODUCTS, NEWTOWN, OHIO  
 SHAPE COMPONENTS, INC., PATTERSON, N.J.  
 SIGMA MACHINERY, ROSEMONT, ILL.  
 SIMOND SAW & STEEL, FITCHBURG, MASS.  
 SMALL BUSINESS ADMIN., DENVER, COLO.  
 SMALL BUSINESS ADMIN., MINNEAPOLIS, MINN.  
 SMALL BUSINESS ADMIN., CLEVELAND, OHIO

SMALL BUSINESS ADMIN., BALA CYNWYD, PA.  
 SMALL BUSINESS ADMIN., SEATTLE, WASH.  
 SMITH, C.W. ENGINEERING CO., INC., MADISON HEIGHTS, MICH.  
 SOUTHERN RESEARCH INSTITUTE, BIRMINGHAM, ALA.  
 SOUTHWORTH MACHINE COMPANY, PORTLAND, ME.  
 SOUTHWESTERN CITY SCHOOL, GROVE CITY, OHIO  
 SPERRY RAND CORPORATION, PHOENIX, ARIZ.  
 SPERRY RAND CORPORATION, GREAT NECK, N.Y.  
 SPERRY RAND CORPORATION, LONG ISLAND CITY, N.Y.  
 STANDARD OIL CO., CHICAGO, ILL.  
 STANDARD OIL CO., - OHIO (THE), CINCINNATI, OHIO  
 STATE OF MICHIGAN, EAST LANSING, MICH.  
 SUNSTRAND CORPORATION, SYRACUSE, N.Y.  
 SYLVANIA ELECTRIC PRODUCTS, WALTHAM, MASS.  
 SYLVANIA HIGH SCHOOL, SWANTON, OHIO

TECHNOLOGY REPORTS, CHESTERLAND, OHIO  
 TECHNICAL PROGRAMMING ASSOC., INC., SMYRA, GA.  
 TELEDYNE COMPANY, BROWN ENGRG. CO., HUNTSVILLE, ALA.  
 TELEDYNE COMPANY, CINCINNATI, OHIO  
 TIBBETTS INDUSTRIES, INC., CAMDEN, ME.  
 TRITON COLLEGE, PHILADELPHIA, PA.  
 TROYAN-KENNEDY COMPANY, CINCINNATI, OHIO  
 TRU-CUT INC., ATLANTA, GA.  
 TRW, INC., PORT CLINTON, OHIO  
 TRW, INC., HARRISBURG, PA.  
 TWIN CITY, ARSENAL, NEW BRIGHTON, MINN.

U.S. AIR FORCE, APO, N.Y.  
 U.S. DEPT. OF COMMERCE, WASHINGTON, D.C.  
 U.S. NAVAL APPLIED SCIENCE LAB., BROOKLYN, N.Y.  
 U.S. NAVY, WASHINGTON, D.C.  
 UTD CORPORATION, DERBY LINE, VT.  
 UNIMET CARBIDES, DIV. OF UNITED GREENFIELD,  
 CHICAGO, ILL.

UNION CARBIDE CORP., TARRYTOWN, N.Y.  
 UNITED AIRCRAFT PRODUCTS, INC., FOREST, OHIO  
 UNITED NUCLEAR CORP., NEW HAVEN, CONN.  
 UNITED SHOE MFG., CORP., (THE), BEVERLY, MASS.  
 UNIVAC, SALT LAKE CITY, UTAH

VAN INDUSTRIES, CINCINNATI, OHIO  
 VARIAN ASSOCIATES, PALO ALTO, CALIF.  
 VITRO LABORATORIES, SILVER SPRINGS, MD.

WAUKESHA CUTTING TOOL, WAUKESHA, WISC.  
 WESTERN MICHIGAN UNIVERSITY, KALAMAZOO, MICH.  
 WESTINGHOUSE ELECTRIC CORP., CHARLOTTE, N.C.  
 WESTINGHOUSE ELECTRIC CORP., MADISON, PA.  
 WESTINGHOUSE ELECTRIC CORP., WEST MIFFLIN, PA.  
 WINDSOR MANUFACTURING, WINDSOR, CONN.  
 WORLD AEROSPACE CORP., MINNEAPOLIS, MINN.  
 WRIGHT-PATTERSON AIR FORCE BASE, FABRICATION  
 MODIFICATION SHOP, WRIGHT-PATTERSON AFB, OHIO

# SUMMARY OF SPECIFIC INQUIRIES BY COMPANIES MAKING 5 OR MORE REQUESTS

October 1, 1984 - September 30, 1988

ABEX CORPORATION	6	INTERNATIONAL NICKEL CO., INC.	20
AEROJET-GENERAL CORPORATION (6)*	27	(THE) (4)*	7
AERONCA INC.	6	JERDEN MANUFACTURING COMPANY	7
AEROSPACE RESEARCH APPLICATION CENTER	12	JONES & LAMSON	7
AIRESEARCH MANUFACTURING CO. (3)*	13	KENAMETAL INC. (3)*	10
ALLIS-CHALMERS MANUFACTURING COMPANY (2)*	19	KRONENBERG, DR. MAX	8
ALTAMIL CORP.	7	LADISH CO.	6
AMERICAN SOCIETY FOR METALS	10	LEBLOND MACHINE TOOL COMPANY, R.K.	14
AMERICAN SOCIETY OF TOOL & MANUFACTURING ENGINEERS	7	LING-TEMCO-VOUGHT, INC. (4)*	7
ARGONNE NATIONAL LABORATORY	7	LOCKHEED AIRCRAFT CORPORATION (5)*	56
ARMCO STEEL CORPORATION (4)*	7	LODGE & SHIPLEY COMPANY, (THE)	6
AVCO CORPORATION (5)*	21	MACHINE DESIGN	5
AMERICAN TOOL WORKS	7	MARQUARDT CORP., (THE) (2)*	7
BARRY-WEHMLER	8	MARQUARDT METAL PRODUCTS COMPANY	6
BATTELLE MEMORIAL INSTITUTE (3)*	30	MARTIN COMPANY (4)*	52
BENDIX CORPORATION (THE) (8)*	63	MASSACHUSETTS INSTITUTE OF TECHNOLOGY	5
BOEING COMPANY (THE) (6)*	51	MASSEY-FERGUSON INC.	5
BOMAR COMPANY	6	MENASCO MANUFACTURING COMPANY (2)*	7
BOOZ ALLEN APPLIED RESEARCH INC. (2)*	6	METALWORKING MAGAZINE	5
BRUSH BERYLLIUM CO. (THE) (3)*	10	METCUT RESEARCH ASSOCIATES INC.	45
BURNDY CORPORATION	5	METEM CORPORATION	8
CALIFORNIA GENERAL INC.	5	MCDONNELL DOUGLAS CORP. (4)*	46
CARBORUNDUM COMPANY	11	MICHIGAN, UNIVERSITY OF	7
CATERPILLAR TRACTOR COMPANY (2)*	5	MONSANTO RESEARCH CORPORATION (3)*	7
CHRYSLER CORPORATION (2)*	5	MOOG INC.	5
CINCINNATI LATHE AND TOOL COMPANY	10	MOREHEAD STATE UNIVERSITY	5
CINCINNATI MILLING MACHINE COMPANY (THE) (2)*	77	NATIONAL AERONAUTICS & SPACE ADMINISTRATION (4)*	5
CINCINNATI SHAPER COMPANY	8	NATIONAL LEAD CO. OF OHIO	20
CINCINNATI, UNIVERSITY OF	8	NEW ENGLAND RESEARCH APPLICATION CENTER	13
CLEVELAND AUTOMATIC MACHINE TOOL COMPANY	5	NORTH AMERICAN ROCKWELL CORP. (8)*	79
CONTINENTAL AVIATION & ENGINEERING CORP. (2)*	10	NORTH CAROLINA STATE UNIVERSITY	5
CORNELL AERONAUTICAL LABORATORY INC.	5	NORTHROP NORAIR	5
CORNING GLASS WORKS	9	NORTON COMPANY	7
CRUCIBLE STEEL COMPANY OF AMERICA (2)*	9	OWENS-ILLINOIS (2)*	7
CUMMINS ENGINE COMPANY, INC.	5	PENNSYLVANIA STATE UNIVERSITY	6
CURTIS-WRIGHT CORP. (3)*	80	PHILCO CORPORATION (2)*	5
DELAVAL TURBINE INC.	5	PLANET PRODUCTS CORP.	9
DO ALL COMPANY (2)*	5	PRATT & WHITNEY AIRCRAFT (3)*	12
DOW CHEMICAL COMPANY (3)*	12	RADIO CORPORATION OF AMERICA (4)*	10
DUPONT DE NEMOURS & CO., E.I. (3)*	32	REACTIVE METALS INC.	11
DYNAMICS CORPORATION OF AMERICA	10	REYNOLDS METAL COMPANY	6
ELECTRICAL MACHINING INC.	5	ROCK ISLAND ARSENAL	19
ELECTRONICS SPECIALTY COMPANY	6	ROHR CORP.	9
ELLIOT COMPANY	8	SANDIA CORP.	15
FEDERAL MONGUL CORPORATION	6	SMALL BUSINESS ADMINISTRATION (6)*	9
FORD MOTOR COMPANY (5)*	15	SOUTHERN ILLINOIS UNIVERSITY	10
GENERAL DYNAMICS CORP. (5)*	56	SPERRY RAND CORP. (9)*	5
GENERAL ELECTRIC CO. (31)*	228	STANDARD OIL CO. (THE) (3)*	5
GENERAL MOTORS CORP. (13)*	35	STEEL MAGAZINE	11
GENERAL PRECISION INC. (3)*	5	SUNDSTRAND CORP., SUNDSTRAND AVIATION	20
GLIDDEN COMPANY (THE)	5	SYLVANIA ELECTRIC PRODUCTS COMPANY	13
GOODYEAR AEROSPACE CORPORATION	14	TRW, INC. (5)*	44
G.A. GRAY COMPANY	5	TELEDYNE INC. (5)*	18
GRUMMAN AIRCRAFT ENGINEERING CORP. (2)*	19	TENNESSEE, UNIVERSITY OF (2)*	6
HAMILTON STANDARD	11	THERM, INC.	15
HOLLEY CARBURETOR COMPANY (2)*	13	THIokol CHEMICAL CORP.	11
HONEYWELL, INC. (4)*	9	TINKER AIR FORCE BASE	23
HUGHES AIRCRAFT COMPANY (4)*	12	TOOL SALES & SERVICE	9
IIT RESEARCH INSTITUTE	6	U.S. NAVAL APPLIED SCIENCE LAB.	7
ILLINOIS, UNIVERSITY OF	8	UNION CARBIDE CORPORATION (5)*	52
INGERSOLL RAND CORP. (3)*	11	VALERON (3)*	7
INTERNATIONAL BUSINESS MACHINE CORP. (8)*	16	VERMONT AMERICAN CORP.	12
		WAYNE STATE UNIVERSITY	21
		WESTERN ELECTRIC CO., INC. (4)*	5
		WESTINGHOUSE ELECTRIC CORP. (10)*	36
		WRIGHT-PATTERSON AIR FORCE BASE (4)*	58
		WYMAN-GORDON COMPANY (2)*	10
		XEROX CORP.	6

( ) \* No. of DIVISIONS

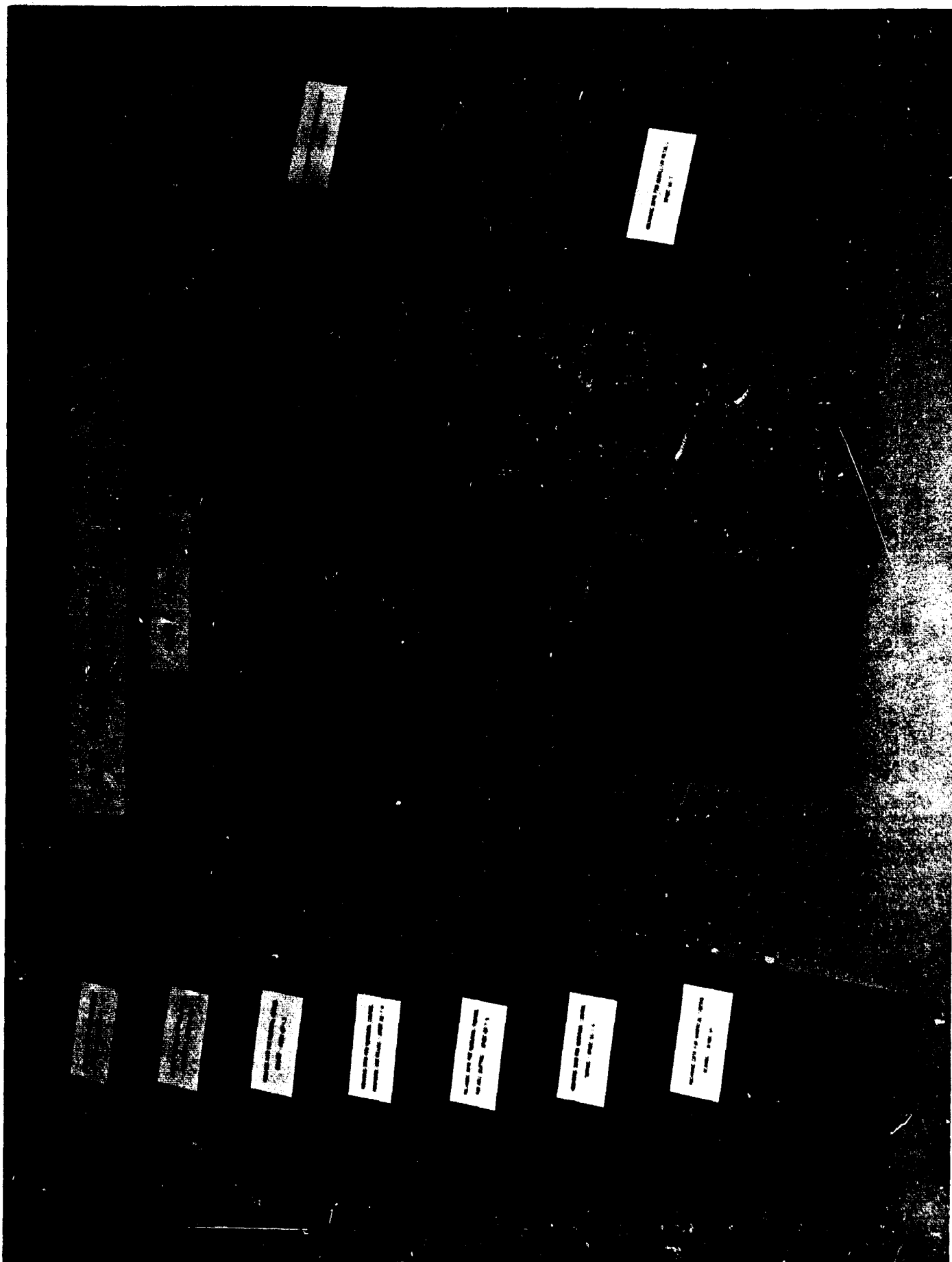


FIGURE 27

**DISCUSSION**



Figure #

## BROADCASTING

[illegible]

combined best falls to be supported for  
a full year. **Maximum Conditions.**  
Due to the complexity of many breeding tests and the  
requirements involved, general production of broods  
are not permitted.

# TYPICAL FORMATS FOR DATA PRESENTATION

## TURNING

MATERIAL	CONDITION & MICROSTRUCTURE	TOOL MATERIAL		TOOL GEOMETRY				CUTTING FLUID	DEPTH OF CUT in.	FEED in. ipr	TOOL LIFE - minutes	
		TRADE NAME	INDUSTRY GRADE	DR°	SR°	SCSA°	EDCA°	RELIEF°	NOSE RADIUS in.			
HIGH TEMPERATURE ALLOYS - NICKEL BASE INCOINEL 718 (cont.)	SOLUTION TREATED & AGED AUSTENITIC	48 R <sub>C</sub>	-	715 HSS	0	15	15	5	.032	.040	.007	.000
												3
												46
INCOINEL 718	SOLUTION TREATED & AGED AUSTENITIC	48 R <sub>C</sub>	C-2		0	5	15	5	.032	.040	.008	.015
												10
												123
									1:20			117
												96

## PERIPHERAL END MILLING

MATERIAL	CONDITION & MICROSTRUCTURE	TOOL MATL.		CUTTER DIA. in.	NO. TEETH	FLUTE LENGTH in.	UP OR DOWN MILL- ING	HELIX ANGLE°	TOOL GEOMETRY		CUT- TING FLUID	DEPTH OF CUT in.	WIDTH OF CUT in.	FEED in. ipt	TOOL LIFE END POINT in.	TOOL LIFE/CUTTER inches work travel vs SPEED-foot/minute R-Recommended Speed
		TRADE NAME	INDUS- TRY GRADE						CHAM- FER	EDGE° REL°						
HIGH TEMPERATURE ALLOYS - NICKEL BASE INCOINEL 718 (cont.)	SOLUTION TREATED & AGED AUSTENITIC	42R <sub>C</sub>	-	.750	4	2	DOWN	30	10	45° .000°	1	.125	.750	.001	.012	24
																11

## DRILLING

MATERIAL	CONDITION & MICROSTRUCTURE	DRILL MATL.		DRILL SIZE			DRILL GEOMETRY			CUTTING FLUID	DEPTH OF HOLE in.	FEED in. ipr	DRILL LIFE END POINT in.	DRILL LIFE NO. OF HOLES vs SPEED-foot/minute R-Recommended Speed
		TRADE NAME	INDUS- TRY GRADE	TYPE	DIA. in.	LENGTH in.	FLUTE LENGTH in.	TYPE POINT	HELIX ANGLE°	POINT ANGLE°	LIP RE- LIEF°			
HIGH TEMPERATURE ALLOYS - NICKEL BASE INCOINEL 718 (cont.)	SOLUTION TREATED AUSTENITIC	245	T15 HSS	TYPE DRILL	.250	2.5	1.375	CRANK- SHAFT	20	110	7	.002	.015	21
														25

FIGURE 20

# DESCRIPTION & DISTRIBUTION OF AFMDC DATA PRODUCTS

August, 1965 - September 30, 1968

DESCRIPTION & CONTENT	DISTRIBUTION		
	USER FILE & DIRECT INQUIRIES	NO. SOLD	TOTAL
AFMDC 65-1, MACHINING DATA FOR TITANIUM ALLOYS, AUGUST 1965 TURNING, FACE MILLING, END MILL SLOTTING, PERIPHERAL END MILLING, DRILLING, REAMING, TAPPING, BROACHING AND SURFACE GRINDING FOR COMMERCIAL PURE TITANIUM, ALPHA-BETA, AND BETA ALLOYS.	4,116	1,567	5,683
AFMDC 66-1, MACHINING DATA FOR NUMERICAL CONTROL, DECEMBER 1966 CONTAINS ALL THE DATA ORIGINALLY PRINTED IN THE 7 INDIVIDUAL REPORTS, AFMDC 66-1.1 THROUGH 66-1.7 LISTED BELOW. (See Notes).	158	811	769
AFMDC 66-1.1, MACHINING DATA FOR NUMERICAL CONTROL-TURNING, JUNE 1966 FREE MACHINING PLAIN CARBON STEELS, PLAIN CARBON STEELS, FREE MACHINING ALLOY STEELS, ALLOY STEELS, ULTRA-HIGH STRENGTH STEELS, TOOL STEELS-HOT WORK, STAINLESS STEELS, TITANIUM ALLOYS, HIGH TEMPERATURE ALLOYS, REFRACTORY ALLOYS, AND NONMETALLICS.	1,081	80	1,171
AFMDC 66-1.2, MACHINING DATA FOR NUMERICAL CONTROL-FACE MILLING, AUGUST 1966 ALLOY STEELS, ULTRA-HIGH STRENGTH STEELS, TOOL STEELS-HOT WORK, STAINLESS STEELS, TITANIUM ALLOYS, HIGH TEMPERATURE ALLOYS, REFRACTORY ALLOYS, AND NONMETALLICS.	1,081	28	1,107
AFMDC 66-1.3, MACHINING DATA FOR NUMERICAL CONTROL-DRILLING, AUGUST 1966 ALLOY STEELS, ULTRA-HIGH STRENGTH STEELS, TOOL STEELS-HOT WORK, STAINLESS STEELS, TITANIUM ALLOYS, HIGH TEMPERATURE ALLOYS, REFRACTORY ALLOYS, AND NONMETALLICS.	1,080	13	1,083
AFMDC 66-1.4, MACHINING DATA FOR NUMERICAL CONTROL-PERIPHERAL END MILLING, SEPTEMBER 1966 ALLOY STEELS, ULTRA-HIGH STRENGTH STEELS, TITANIUM ALLOYS, HIGH TEMPERATURE ALLOYS, AND REFRACTORY ALLOYS.	1,080	2	1,082
AFMDC 66-1.5, MACHINING DATA FOR NUMERICAL CONTROL-END MILL SLOTTING, SEPTEMBER 1966 ALLOY STEELS, ULTRA-HIGH STRENGTH STEELS, TOOL STEELS-HOT WORK, STAINLESS STEELS, TITANIUM ALLOYS, HIGH TEMPERATURE ALLOYS, AND REFRACTORY ALLOYS.	1,083	2	1,085
AFMDC 66-1.6, MACHINING DATA FOR NUMERICAL CONTROL-TAPPING, NOVEMBER 1966 ALLOY STEELS, ULTRA-HIGH STRENGTH STEELS, TOOL STEELS-HOT WORK, STAINLESS STEELS, TITANIUM ALLOYS, HIGH TEMPERATURE ALLOYS, REFRACTORY ALLOYS, AND NONMETALLICS.	1,080	-	1,080
AFMDC 66-1.7, MACHINING DATA FOR NUMERICAL CONTROL-REAMING, NOVEMBER 1966 ULTRA-HIGH STRENGTH STEELS, TITANIUM ALLOYS, HIGH TEMPERATURE ALLOYS, AND REFRACTORY ALLOYS.	1,080	-	1,080
AFMDC 66-2, GRINDING RATIOS FOR AEROSPACE ALLOYS, JUNE 1966 SURFACE GRINDING OF ALLOY STEELS, ULTRA-HIGH STRENGTH STEELS, TOOL STEELS, STAINLESS STEELS, TITANIUM ALLOYS, HIGH TEMPERATURE ALLOYS, REFRACTORY ALLOYS AND NONMETALLICS.	898	174	872
AFMDC 66-3, MACHINING DATA FOR BERYLLIUM METAL, JUNE 1966 THIS BOOKLET COVERS PROBLEMS INVOLVED IN MACHINING BERYLLIUM, IN ADDITION TO SPECIFIC DATA FOR 10 CONVENTIONAL OPERATIONS AND 4 ALTERNATE MACHINING METHODS.	727	358	1,085
AFMDC 66-1, DETERMINATION AND ANALYSIS OF MACHINING COST AND PRODUCTION RATES USING COMPUTER TECHNIQUES, AUGUST 1968 THIS DATA PRODUCT DESCRIBES A PRACTICAL APPROACH TO THE PROBLEM OF OBTAINING MACHINING COSTS AND PRODUCTION RATES. IT INCLUDES EQUATIONS, NUMEROUS COMPUTER CALCULATIONS AND COMPUTER SOURCE PROGRAM LISTINGS.	.	.	.
AFMDC 66-2, 1968 SUPPLEMENT TO MACHINING DATA FOR NUMERICAL CONTROL, AUGUST 1968 THIS SUPPLEMENT IS A COMPANION VOLUME TO MACHINING DATA FOR NUMERICAL CONTROL (AFMDC 66-1). MACHINING DATA ARE PRESENTED FOR THE NEER AEROSPACE MATERIALS.	.	.	.
TOTALS	13,214	2,833	16,047

\* No statistics available since this data product was only recently announced.

## DATA ACQUISITION PLANT VISIT PROGRAM

### LIST OF COMPANIES THROUGH SEPTEMBER 30, 1968

Aerjet-General Corporation  
Sacramento, California

Aerospace Research Applications Center  
Bloomington, Indiana

AiResearch Manufacturing Company  
Phoenix, Arizona

American Bosch Arms Corporation  
Garden City, New York

American Welding & Manufacturing Company  
Warren, Ohio

Argonne National Laboratory  
Argonne, Illinois

Avco Corporation  
Nashville, Tennessee

Beech Aircraft Corporation  
Wichita, Kansas

Bell Helicopter Company  
Ft. Worth, Texas

Bendix Corporation  
Teterboro, New Jersey

Boeing Company (The)  
Wichita, Kansas

Boeing Company (The) (2)\*  
Seattle, Washington

General Dynamics Corporation  
San Diego, California

General Dynamics Corporation  
Ft. Worth, Texas

General Electric Company  
Phoenix, Arizona

Giddings & Lewis Inc.  
Fond Du Lac, Wisconsin

Grinding Wheel Institute  
Pittsburgh, Pennsylvania

Hughes Aircraft Company  
Tucson, Arizona

Hughes Aircraft Company  
Culver City, California

Kaiser Aerospace & Electronics  
San Leandro, California

Ling-Temco-Vought, Inc.  
Dallas, Texas

Lockheed Aircraft Corporation (2)\*  
Burbank, California

Lockheed-Georgia Company  
Marietta, Georgia

Lockheed Aircraft Corporation  
Sunnyvale, California

Los Angeles Pierce College  
Woodland Hills, California

Martin Company  
Orlando, Florida

Menasco Manufacturing Company  
Burbank, California

McDonnell Douglas Corporation  
Santa Monica, California

McDonnell Douglas Corporation  
St. Louis, Missouri

North American Rockwell Corporation  
Anaheim, California

North American Rockwell Corporation  
Downey, California

North American Rockwell Corporation (2)\*  
Canoga Park, California

North American Rockwell Corporation (3)\*  
Los Angeles, California

Northrop Norair  
Hawthorne, California

Northrop Ventura  
Newbury Park, California

P Pratt & Whitney Aircraft  
West Palm Beach, Florida

RCA  
Camden, New Jersey

Sandia Corporation  
Albuquerque, New Mexico

Solar/Div. of International Harvester  
San Diego, California

Sperry Gyroscope Company  
Great Neck, New York

Sperry Rand Corporation  
Sperry Flight Systems Division  
Phoenix, Arizona

Tinker Air Force Base  
Oklahoma City, Oklahoma

Union Carbide Corporation  
Oak Ridge, Tennessee

Western Electric Company, Inc.  
Oklahoma City, Oklahoma

Westinghouse Electric Corporation  
Sunnyvale, California

( )\* more than one visit

# CODE SHEET FOR PROJECT TIME CARD

(USED BY EMPLOYEES FOR RECORDING HOURS ON DAILY TIME CARDS)

<u>DIRECT LABOR</u>	1000	<u>DATA ACQUISITION - LITERATURE</u>	1270
<u>INQUIRIES</u>	1100	INDUSTRIAL CONTRIBUTORS OF MACHINING	
ENGINEERING SUPERVISION*	1110	REPORTS AND CASE HISTORIES	1271
INQUIRY STRATEGY AND INQUIRY APPROVAL	1111	DOMESTIC PERIODICAL LITERATURE	1272
<u>MACHINING DATA ANALYSIS</u>	1120	FOREIGN PERIODICAL LITERATURE	1273
ANSWERING INQUIRIES	1121	INDUSTRIAL TRADE LITERATURE	1274
<u>DATA PROCESSING</u>	1130	TECHNICAL INSTITUTIONS, PROFESSIONAL	
KEYPUNCHING	1131	SOCIETIES, AND ASSOCIATIONS	1275
VERIFICATION	1132	PUBLISHERS OF HANDBOOKS, MANUALS, BOOKS	1276
SORTING	1133	INFORMATION CENTERS	1277
CODING	1134	GOVERNMENT AGENCIES	1278
DECODING	1135	MACHINABILITY LABORATORIES	1279
COMPUTER PROCESSING	1136	<u>DATA ACQUISITION - BY TECHNICAL PERSONNEL</u>	1280
<u>DATA CONTROL</u>	1140	PLANT VISITS	1281
FORMS AND DOCUMENT HANDLING	1141	TELEPHONE, TWX, TELEGRAM	1282
<u>DATA ACQUISITION*</u>	1150	LETTERS	1283
SPECIAL ACQUISITION FOR INQUIRIES	1151	TECHNICAL MEETINGS (MACHINABILITY)	1284
<u>REPRODUCTION*</u>	1160	TECHNICAL MEETINGS (INFORMATION SCIENCE)	1285
XEROX	1161	FOREIGN PLANT VISITS	1286
DITTO	1163	FOREIGN TECHNICAL MEETINGS	1287
DRAWING	1165	INDUSTRY SPECIAL	1288
<u>SYSTEMS ANALYSIS</u>	1170	<u>DATA STORAGE</u>	1290
TECHNICAL REVIEW	1171	DOCUMENT FILE	1291
COST EVALUATION	1172	SUPPORT INFORMATION (BOOKS, ETC.)	1292
<u>VISITS TO AFMDC - TECHNICAL*</u>	1180	<u>GENERAL DISSEMINATION OF MACHINABILITY</u>	
MANUFACTURING TECHNOLOGY DIVISION	1181	<u>DATA AND CENTER INFORMATION</u>	1300
OTHERS	1182	PUBLICATION IN TECHNICAL LITERATURE	1310
<u>ORIGINAL DATA ENTRY</u>	1200	PRESENTATION AT TECHNICAL MEETINGS	1311
ENGINEERING SUPERVISION	1210	PRESENTATION AT PLANTS	1312
TECHNICAL PLANNING	1211	AFMDC EXHIBITS	1320
<u>MACHINING DATA ANALYSIS</u>	1220	NEWSPAPERS (METALWORKING, ETC.) & MAGAZINES	1330
PRELIMINARY SCREENING	1221	USER LIST (TECHNICAL ASPECTS)	1340
PRELIMINARY TECHNICAL EVALUATION	1222	USER LIST PRODUCTS	1350
FINAL TECHNICAL EVALUATION (put Document		AFMDC PAMPHLETS, ANNOUNCEMENTS, ETC.	1360
Control No. on Daily Time Slip)	1223	SPECIAL REPORTS (STATE-OF-THE-ART, ETC.)	1370
<u>DATA PROCESSING</u>	1230	BIBLIOGRAPHIES	1380
KEYPUNCHING	1231	<u>AFMDC SYSTEM REPORTS AND MEETINGS</u>	1400
VERIFICATION	1232	MONTHLY (MTD)	1410
SORTING	1233	QUARTERLY (MTD)	1420
CODING	1234	ANNUAL (MTD)	1430
DECODING	1235	OPERATIONS MANUAL	1440
COMPUTER PROCESSING	1236	DETAILED CODE BOOK	1450
<u>DATA CONTROL</u>	1240	AFMDC MEETINGS	1460
FORMS AND DOCUMENT HANDLING	1241	MANUFACTURING TECHNOLOGY DIVISION AND	
<u>REPRODUCTION</u>	1250	INFORMATION BRANCH MEETINGS, REPORTS,	
XEROX	1251	AND CONFERENCES	1470
DRAWING OF DATA SHEETS, ETC.	1253	SPECIAL REPORTS FOR MANUFACTURING TECHNOLOGY	
<u>SYSTEMS ANALYSIS</u>	1260	DIVISION, DOD, ETC.	1480
TECHNICAL REVIEW	1261	<u>MACHINING DATA VERIFICATION - EXPERIMENTAL</u>	1500
COST EVALUATION	1262	(PROVISIONAL + PRESENTLY INACTIVE)	
DATA ACQUISITION EVALUATION	1263	PLANNING	1501
		TESTING	1502
		REPORTS	1503

\*Put Inquirer and Sequence numbers in Operation space on Time Card  
The Inquirer No. and Sequence No. are those blocked out at the top  
of IF-1 as shown here:




# CODE SHEET FOR PROJECT TIME CARD (continued)

<u>SYSTEMS ANALYSIS - GENERAL</u>	1600
1130 COMPUTING SYSTEM (SYSTEMS ASPECTS)	1610
STATISTICAL PROGRAM FOR ANALYSIS OF CENTER EFFECTIVENESS (SPACE)	1620
1130 COMPUTING SYSTEM (TECHNICAL ASPECTS)	1630

<u>INDIRECT LABOR</u>	0000
GENERAL REPAIR, CLEANING, PAINTING	0101
TRAINING	0102
SICKNESS OR EXCUSED ABSENCE	0103
VACATION	0104
ACQUISITION OF MAJOR FACILITIES AND EQUIPMENT	0105
ACQUISITION OF MINOR EQUIPMENT AND SUPPLIES	0106
PROPOSALS AND SETTING UP PROGRAMS	0116
TECHNICAL MEETINGS AND PAPERS (NOT DIRECTLY RELATED TO AFMDC)	0127
GENERAL AFMDC CLERICAL AND OFFICE WORK	0128
GENERAL AFMDC ADMINISTRATION	0150
TYPING AND CLERICAL ON INQUIRIES	0151
TYPING AND CLERICAL ON ORIGINAL DATA ENTRIES	0152
HANDLING OF MAIL	0153
PERSONNEL (HIRING, ETC.)	0154
USER FILE (TYPING AND CLERICAL)	0155
VISITORS (TRANSPORTATION, SYSTEM DEMONSTRATION, GENERAL AFMDC INFORMATION)	0156
DATA PROCESSING (TIME CARDS, ETC.)	0157
TYPING AND CLERICAL ON USER PRODUCTS	0158
MISCELLANEOUS AFMDC NONCHARGEABLE SERVICES	0159
LIBRARY-SUPPORT INFORMATION	0160

<u>PURCHASES</u>	
FOR PURCHASES PRECEDE CODE BY:	800
<u>Examples:</u>	
800-1230 IBM CARDS FOR DATA PROCESSING, ETC.	
800-0000 INDIRECT CHARGES SUCH AS GENERAL SUPPLIES	
800-1272 PURCHASE OF DOMESTIC PERIODICAL LITERATURE	

EMPLOYEE'S OPERATIONAL  
AREA (MACHINING DATA  
ANALYSIS)

EMPLOYEE NUMBER

**METCUT RESEARCH ASSOCIATES INC.**

## ANSWERING INQUIRIES

**SPECIFIC COMPANY  
MAKING INQUIRY**

OPERATIONAL  
AREA  
(MACHINING  
DATA ANALYSIS-  
CODE 4)

SEQUENTIAL  
NUMBER OF  
SPECIFIC  
INQUIRY

# FINAL TECHNICAL EVALUATION

DOCUMENT NUMBER  
ASSIGNED TO DATA  
PRODUCT (IN  
PROCESS)

WORK IN  
ANOTHER  
OPERATIONAL  
AREA (DATA  
ACQUISITION-  
CODE 7)

8.0

**APPROVED**

## TIMEKEEPER



# COMPUTER PRINTOUT OF AFMDC PROJECT TIME CARDS

FIGURE 33

PROJECT CLASS	LABOR TYPE	EMPLOYEE INFORMATION NUMBER	FIRST-NAME-LAST	ELAPSED HOURS	DATE	PROJECT NUMBER-INDEX	LIST PAYROLL
5	1231	1	5 459	V	HEITKEMPE	1.50 9 16 68 950999	68
5	1241	1	5 459	V	HEITKEMPE	1.00 9 16 68 950999	68
		5	459			2.50	***
5	1136	1	5 384	C	CROCKETT	4.00 9 17 68 950999	68
5	1232	1	5 384	C	CROCKETT	1.00 9 18 68 950999	68
5	1430	1	5 384	C	CROCKETT	2.50 9 19 68 950999	68
		5	384			7.50	***
4	1350	1	4 240	A	F ACKENHAUS	0.50 9 19 68 950003	68
4	1350	1	4 240	A	F ACKENHAUS	1.50 9 19 68 950003	68
4	1350	1	4 240	A	F ACKENHAUS	2.50 9 20 68 950006	68
		4	240			4.50	***
4	1223	1	4 235	C	MEHL	2.00 9 13 68 950999	68
4	1223	1	4 235	C	MEHL	5.00 9 14 68 950999	68
4	1223	1	4 235	C	MEHL	6.50 9 18 68 950999	68
		4	235			13.50	***
4	1121	1	4 220	R	SNIDER	1.00 9 23 68 0846 11029	
4	1121	1	4 220	R	SNIDER	1.00 9 24 68 0154 11055	
4	1121	1	4 220	R	SNIDER	1.00 9 25 68 0024 11063	
4	1121	1	4 220	R	SNIDER	1.00 9 26 68 0028 11058	
		4	220			4.00	***
2	1111	-	2 101	J	MARANCHIK	2.00 9 23 68 950999	68
2	1430	-	2 101	J	MARANCHIK	2.00 9 24 68 950999	68
		2	101			4.00	***
DECK TOTAL HOURS =							36.00

50

SEE APPENDIX, PAGE A-18

# AFMDC OPERATING COSTS

FEBRUARY 1, 1988 - SEPTEMBER 30, 1988

INPUT COSTS		
TECHNICAL EVALUATION	\$	28,483.81
DATA PROCESSING		18,778.83
DOCUMENT ACQUISITION & REPRODUCTION		11,467.88
		58,731.40
EQUIPMENT, SUPPLIES & SERVICES		8,203.83
	TOTAL	84,835.33
OUTPUT COSTS		
INQUIRIES:		
TECHNICAL EVALUATION	\$	37,027.81
DATA PROCESSING & RETRIEVAL		8,858.71
DATA ACQUISITION & REPRODUCTION		4,847.14
		51,333.48
DATA PRODUCTS:		
DATA PRODUCTS COMPLETED & IN PROCESS (INCLUDING PRINTING COSTS)	\$	18,352.07
REPRINTING OF USAF MACHINABILITY REPORTS		4,289.00
		22,641.07
EQUIPMENT, SUPPLIES & SERVICES		5,297.00
		27,938.07
	TOTAL OUTPUT	\$ 78,271.53
GENERAL DISSEMINATION		
GENERAL DISSEMINATION OF MACHINABILITY DATA & CENTER INFORMATION	\$	2,917.41
EQUIPMENT, SUPPLIES & SERVICES		282.00
	TOTAL	3,199.41
REPORTS		
AFMDC SYSTEMS REPORTS	\$	1,780.77
THIRD ANNUAL REPORT - PREPARATION & PRINTING		5,353.43
FOURTH ANNUAL REPORT - PREPARATION & PRINTING		2,614.05
AFMDC, MTD AND INFORMATION BRANCH MEETINGS AND SPECIAL MTD REPORTS		5,258.07
		15,016.32
EQUIPMENT, SUPPLIES & SERVICES		3,424.00
	TOTAL	18,440.32
SYSTEMS ANALYSIS, MODIFICATION & CONTROL		
TECHNICAL EVALUATION	\$	2,099.84
DATA PROCESSING - IBM 1130 COMPUTING SYSTEM:		
TECHNICAL ASPECTS		820.54
SYSTEMS ASPECTS		7,840.83
OPERATIONS MANUAL & CODE BOOK REVISIONS & ADDITIONS		1,497.51
		12,048.52
EQUIPMENT, SUPPLIES & SERVICES		1,260.09
	TOTAL	13,308.61
TOTAL ACTUAL COSTS NOT INCLUDING FIXED FEE		\$ 178,155.20

# AFMDC INPUT & OUTPUT SUMMARY

October 1, 1964 - September 30, 1968

## SYSTEM INPUT

### Document and Card Totals

Documents Entered into the System (including Specific Inquiries)

Oct. 1, 1964 - Jan. 31, 1967	17,576
Feb. 1, 1967 - Jan. 31, 1968	3,695
Feb. 1, 1968 - Sept. 30, 1968	<u>2,341</u>
<b>Total</b>	<b>23,612</b>

Evaluated Documents (including Specific Inquiries)

Oct. 1, 1964 - Jan. 31, 1967	9,367
Feb. 1, 1967 - Jan. 31, 1968	3,734
Feb. 1, 1968 - Sept. 30, 1968	<u>2,840</u>
<b>Total</b>	<b>15,941</b>

Total Cards Punched

Oct. 1, 1964 - Jan. 31, 1967	75,173
Feb. 1, 1967 - Jan. 31, 1968	27,077
Feb. 1, 1968 - Sept. 30, 1968	<u>13,833</u>
<b>Total</b>	<b>116,083</b>

## SYSTEM OUTPUT

### Specific Inquiries

Inquiries Received October 1, 1964 - January 31, 1966	595
Individual Companies Represented	314
U.S. Government Standard Industrial Classification (SIC) Represented	72
Inquiries Received February 1, 1966 - January 31, 1967	736
Individual Companies Represented	396
U.S. Government Standard Industrial Classification (SIC) Represented	90
Inquiries Received February 1, 1967 - January 31, 1968	1,002
Individual Companies Represented	485
Individuals Represented	690
U.S. Government Standard Industrial Classification (SIC) Represented	96
Inquiries Received February 1, 1968 - September 30, 1968	982
Individual Companies Represented	439
Individuals Represented	596
U.S. Government Standard Industrial Classification (SIC) Represented	105

### Data Products

	Copies Distributed	Unit Costs (Preparation & Printing)
AFMDC 65-1, Machining Data for Titanium Alloys	5,683	\$ 1.04
AFMDC 66-1, Machining Data for Numerical Control	769	\$ 6.34
AFMDC 66-1.1, Machining Data for Numerical Control-Turning	1,171	\$ 4.07
AFMDC 66-1.2, Machining Data for Numerical Control-Face Milling	1,107	\$ 3.66
AFMDC 66-1.3, Machining Data for Numerical Control-Drilling	1,083	\$ 3.65
AFMDC 66-1.4, Machining Data for Numerical Control-Peripheral End Milling	1,082	\$ 1.11
AFMDC 66-1.5, Machining Data for Numerical Control-End Mill Slotting	1,065	\$ 1.58
AFMDC 66-1.6, Machining Data for Numerical Control-Tapping	1,060	\$ 1.24
AFMDC 66-1.7, Machining Data for Numerical Control-Reaming	1,060	\$ 0.85
AFMDC 66-2, Grinding Ratio for Aerospace Alloys	672	\$ 3.50
AFMDC 66-3, Machining Data for Beryllium Metal	1,095	\$ 5.98
<b>Total</b>	<b>16,047</b>	

### Unit Costs

Per Inquiry (595) - Oct. 1964 - Jan. 1966	\$47.49
Per Inquiry (736) - Feb. 1966 - Jan. 1967	45.02
Per Inquiry (1002) - Feb. 1967 - Jan. 1968	52.66
Per Inquiry (982) Feb. 1968 - Sept. 1968	58.58
Per Inquiry (3315) - Oct. 1964 - Sept. 1968	50.94

## FUTURE PLANNING

### MAJOR GOALS

1. Increase utilization of AFMDC to meet the needs of industry personnel who have the responsibility for producing hardware and solving machining problems.
2. Continue to identify and make personal contacts with personnel in all echelons who can utilize machining information available from the Center. Emphasis will be given to contractors, subcontractors, and sub-subcontractors producing components for advanced aerospace vehicles.
3. Set up seminars at AFMDC and in selected areas whereby key personnel involved in manufacture of advanced aerospace vehicles will be invited to attend. One of the prime subjects to be discussed at these seminars will be the machining of titanium alloys which will be in heavy usage in these vehicles.
4. Continue the program of plant visitation to make industry aware of the data stored by AFMDC and to obtain cooperation of input to AFMDC.
5. Continue coordination with the active State Technical Services Program in California, Connecticut, Georgia, Illinois, Indiana, Iowa, Michigan, Ohio, New York, Tennessee and West Virginia. Contact will be made with other states which have set such programs into operation. Also, close cooperation will continue with the National Referral Center and other centers.
6. Participation in the special merit project with the State of Vermont, along with another DoD Information Center, namely, PLASTECH. The overall objectives are: a) to establish access to appropriate information analysis centers through the University of Vermont Technical Information Center and b) to test the information transfer relationship between individual companies (requesting information), information analysis centers, and the Technical Information Center (acting as a coupler).
7. Participation in a Special Merit Project with the State of New York with objectives similar to those cited for the State of Vermont. AFMDC is the only information center to be used in this study.
8. Establish closer coordination with the Foreign Technology Division for the purpose of more extensive utilization of the foreign literature in their files and wider dissemination of this information.
9. AFMDC will expand its services to vocational schools, whose programs include machining, through the State Technical Services Program and by direct contact.
10. Provide users with a list of the materials, operations, and keywords used by the Data Center to index documents.
11. Continue the program by which inquirers who submit specific inquiries are kept up-to-date on a periodic basis.
12. Prepare at least the following three data products:
  - a) Machine Tool Requirements, Average Unit Power and Surface Finish Data for Aerospace Materials.
  - b) Tool Geometry Nomenclature and Recommendations.
  - c) Applications of New Tool Materials.
  - d) Supplement to Machining Data for Titanium Alloys.

Consideration will be given to the preparation of several other data products.

13. Continue the analyses of the considerable hard machining data in AFMDC storage with the assist of the computer. The main objective is to determine what relationships and correlations may exist between the various types of machining operations and work materials.
14. Continue to study the potential of a computer data-link by users of the Center.
15. AFMDC will develop detailed plans designed to provide income for the output operation of the Center and increased use of the Center. The particular subjects to be considered are data products and inquiries.
16. Continue to implement the program Statistical Program for Analysis of the Center Effectiveness (SPACE) with emphasis on identifying key people involved in machining of advanced aerospace components, analysis of inquiries and machining information requirements, analysis of the quality of the documents in the system and their utilization in answering inquiries, and preparation of data products.

## ECONOMIC ENVIRONMENT FOR AFMDC OPERATIONS

(Annual Costs)

### Labor and Overhead Costs for Operating Metal Cutting Machine Tools in the Metalworking Industries in the United States

Total number of metal cutting machine tools in the metalworking industries (June 10, 1963, American Machinist Inventory of Metalworking Equipment) = 2,137,497

Average labor cost + overhead = \$8.00 per hour

Average working day = 8 hours

Number of working days per year = 250

Average number of direct labor personnel per machine = 1

Total Cost of Labor + Overhead:

$2,137,497 \times \$8.00 \times 8 \times 250 \times 1 = \$34,199,952,000$  or about

\$34,000,000,000

Based on the 1963 Inventory and actual 1964 and 1965 metal cutting machine tool shipments, American Machinist estimates that 2,500,000 machine tools were in use at the end of 1965. Using this projection, the \$34,000,000,000 would be revised to \$40,000,000,000.

Total Cost of Labor + Overhead:

$2,500,000 \times \$8.00 \times 8 \times 250 \times 1 = \$40,000,000,000$

\$40,000,000,000

### Total Shipments Including Exports of Metal Cutting Type Metalworking Machinery

\$1,040,766,000 (1965)

Source: U.S. Department of Commerce

### Machine Tool Accessories Industry

\$971,000,000

(including small cutting tools for machine tools and metalworking machinery in the amount of \$598,000,000)

Source: 1965 Census of Manufacturers  
Bureau of Census

### Cutting Fluids

\$35,000,000

Source: "Coolant Control... a plant study plan" by B. F. Wilson, Automatic Machining, June 1965.



# POTENTIAL FOR AFMDC SERVICES TO INDUSTRY

STATISTICAL SUMMARY OF METALWORKING PLANTS PARTIAL LIST FROM DEN & BRADSTREET METALWORKING, DIRECTORY 1967-68					AFMDC SUMMARY OF INQUIRIES FOR 8 SIC GROUPS OCTOBER 1, 1964 - SEPTEMBER 30, 1968	
STANDARD INDUSTRIAL CLASSIFICATION (SIC) NUMBER & INDUSTRY CLASSIFICATION	MAJOR PRODUCT MANUFACTURED NO. OF COMPANIES*	MAJOR PRODUCT MANUFACTURED NO. OF INDIVIDUALS	MINOR PRODUCT MANUFACTURED NO. OF COMPANIES	INQUIRERS	NO. OF AFMDC COMPANIES	
MAJOR GROUP 37 - TRANSPORTATION EQUIPMENT SIC INDUSTRY NO.						
3721 - Aircraft & Missiles	74	22,197	7	637		43
3722 - Aircraft Engines & Parts	119	185,333	69	304		30
3723 - Aircraft Propellers & Propeller Parts	13	11,284	12	-		
3729 - Aircraft Parts & Auxiliary Equipment	509	189,521	380	115		57
MAJOR GROUP 33 - PRIMARY METAL INDUSTRIES	3,669	1,360,594	2,442	212		68
MAJOR GROUP 34 - FABRICATED METAL PRODUCTS, EXCEPT ORDNANCE, MACHINERY & Transportation Equipment	10,241	1,296,147	6,842	158		63
MAJOR GROUP 35 - MACHINERY, EXCEPT ELECTRICAL	9,933	1,941,820	7,345	704		326
MAJOR GROUP 36 - ELECTRICAL MACHINERY, EQUIPMENT & SUPPLIES	4,793	1,893,641	2,966	229		81
	29,431	6,900,557	20,063	2,359		668

\* 20 or more employees

**COST SAVINGS RESULTING FROM AFMDC'S OPERATION**

OCTOBER 1, 1984 - SEPTEMBER 30, 1985

**COST SAVINGS RESULTING FROM AFMDC'S  
RESPONSE TO SPECIFIC INQUIRIES**

Total Number of Specific Inquiries 3,315

Estimated Total Number of Machining Situations Included in the 3,315  
Inquiries - 17,163

Estimated Savings per Machining Situation Response - \$800.00

Estimated Total Savings Resulting from Specific Inquiries - 17,163  
Machining Situations x \$800.00 - \$13,730,000.00

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**COST SAVINGS RESULTING FROM AFMDC'S 11 DATA PRODUCTS**

Total Number of Data Product Copies Distributed - 16,047

Estimated Number of Machining Situations Utilized per Data  
Product Copy - 5

Estimated Total Number of Machining Situations - 16,047 Data Product  
Copies x 5 - 80,235

Estimated Savings per Machining Situation - \$300.00

Estimated Total Savings Resulting from Data Products - 80,235 Machining  
Situations x \$300.00 - \$24,070,000.00

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**Total Estimated Cost Savings Resulting from AFMDC'S Operation**

**\$37,800,000.00**

## APPENDIX

### Description of AFMDC (page 1)

This description of AFMDC is distributed by the Center in the form of a pink flyer (3-1/2" x 7-1/2" ) with the information relating to Scope, Collection, and Information Services on one side of the card and with instructions on how to request machining information from AFMDC on the other side. The pink flyer is convenient in size which makes it possible to include it in all types of mailings and to use it for hand-outs at meetings and for Center visitors. Various plants have also used AFMDC flyers to acquaint machining personnel with Center services.

By including detailed information on how to request machining information, it is hoped that some loss in time can be avoided and that the search strategy required will be simplified. Information shown on page 1 has also been furnished for the Air Force Materials Information Centers (AFMIC) booklet, February 1968

### AFMDC Organization Chart (Figure 1, page 2)

This Organization Chart is self-explanatory, but certain comments may be helpful toward gaining a fuller understanding of the basic plan. One of the most important aspects of AFMDC's organization relates to use of engineering personnel. These persons are professionally trained, experienced people who have the capability of judging the value of machining information for input purposes and to make technical analyses of output used for answering specific inquiries as well as developing data products.

Systems Analysts are employed on a part-time basis, with emphasis being placed in three areas: 1) Data Processing, 2) Document Processing, and 3) Data Acquisition. Consultants are used to a limited extent.

Up to the present time, almost complete emphasis on document acquisition has been given to domestic considerations. Since the foreign literature and foreign efforts relating to machinability are significant, this area has been covered by using a consultant to report on foreign trends as they may influence need for domestic cognizance.

Since AFMDC is operated by Metcut Research Associates Inc., full advantage is taken of the capabilities of Metcut personnel not associated with AFMDC on a full-time basis. This includes Dr. Michael Field, president of Metcut, Mr. Norman Zlatin, vice-president of Metcut, Dr. John F. Kahles, vice-president of Metcut, and Mr. John Christopher, who is a project engineer in charge of experimental machining data being developed at Metcut.

Since metal removal is a very complex technical discipline, it is obvious that not all of the capability required can be centered in one organization, and therefore use has been made of part-time analysts located at several companies.

Two important areas of AFMDC systems are document acquisition and data processing. Document acquisition is responsible for acquiring input from both domestic and foreign sources covering the entire broad scope of machining information required to meet the output of the Center. Data processing is a key function required for storage and retrieval of the detailed evaluated and coded information extracted by Machining Data Analysts. Mechanical processing of data was accomplished prior to July 1, 1966, by Electrical Accounting Machine (EAM) equipment. Part of this equipment now supports the IBM 1130 computer, which is the medium for storage and retrieval of processed information.

From an information point of view, the Organization Chart also reflects handling aspects of information which do not require full-time activity. Trained competent secretarial personnel handle activities of the files pertaining to inquiries and data products.

Part-time Systems Analysts are used to develop required computer programs and systems evaluation of current operations. Capability of full-time engineering and data processing personnel has been developed to supplement the effort now being expended by part-time Systems Analysts.

#### AFMDC Operational Areas (page 3)

Each of the functional areas of operation of AFMDC has been assigned a code number from 1 through 9 and 0. These time codes are used in connection with the codes shown in Figure 31, pages 47 and 48, Code Sheet for Project Time Card. For example, a Machining Data Analyst in functional area No. 4 who is answering inquiries will use the code 4-1121. If a Machining Data Analyst in area No. 4 is performing in another operational area, such as assisting in technical aspects of document acquisition by obtaining data from industrial plants (see Figure 31, time code 1281), he will use the time code 7-1281. Since the project time card also includes his employee number and the operational area in which he functions, it is possible to determine the extent of time spent by employees in their principal assigned area as compared with time they spend in other functional areas of the Center (see actual Daily Time Slip, Figure 32, page 49). More important, the stored punched card information from the project time card is valuable in providing detailed analyses of the various cost aspects pertaining to the Center's operation.

#### AFMDC Operations Chart (Figure 2, page 4)

Basically the Operations Chart divides functions into two principal parts: 1) System Input, and 2) System Output. The other function shown in the heading is System Analysis and is linked to input and output to

insure and measure the effectiveness of the two major functions. All sources of information are referenced as 'documents' regardless of whether they are journals, books, technical reports, data sheets, microfilm, abstracts, etc.

System Input consists of the steps shown in Figure 2 which are designed to accept any type of document from any source and process it so that each document becomes an entity within the system. The steps are set so that documents may be evaluated as to the nature of the information contained in view of the computer programs and codes which were established and are modified by System Analysis. In the preliminary screening step judgments are made by engineering personnel as to whether documents received at AFMDC have valuable machining information. The selected documents are then sent on to engineering personnel for technical evaluation and the important information is extracted and recorded using established codes and formats.

Due to the large backlog of unprocessed documents on hand at the beginning of operation of AFMDC, a decision was made to process documents through the step called Preliminary Technical Evaluation. This evaluation identified only seven parameters of a machining situation, if available, 1) machining operation, 2) material hardness, 3) material condition, 4) heat treatment, 5) material group, 6) material description, 7) tool material. At this step all documents were assigned uniterms where applicable to describe the text to the system. These uniterms, together with the source control number, are punched into card formats. Examples of computer printouts of searches made on the Preliminary Technical Evaluation and Uniterm Files are shown in Figures 8 and 9, pages 11 and 12. This mode of evaluation allowed for rapid access to documents in AFMDC storage. As of April 1, 1967, the Preliminary Technical Evaluation step was eliminated and all incoming documents selected in Preliminary Screening are routed directly to Final Technical Evaluation. In this phase of the processing all of the significant reported information for each machining situation is extracted, including numerical data and tool geometry. The extracted information is placed on the forms shown in Figure 5, page 8. These forms are given to a keypunch operator who punches cards which will be stored on the computer. A printout of this type of information is shown in Figure 10, page 13.

System output consists of the three basic types of output: 1) specific inquiries, 2) data products, and 3) general dissemination. Specific inquiries may be submitted to AFMDC by anyone qualified as a User of AFMDC. The request may be for specific data for a machining situation or series of machining operations, state-of-the-art studies, etc. A list of the types of inquiries is shown in Figure 19, page 23.

Data products are published by AFMDC on timely subjects which are comprehensive studies and generally take the form of charts of data for one or more alloys. The charts contain all the known data for machining parameters, tool geometry, cutting fluid, tool material and other considerations directly applicable to the machining situation. When data products become available a notice is sent to every individual on the User File. Through this notice the User is made aware of information that may be applicable to his needs.

General dissemination takes the form of plant visits for coordination (see page 46), writing technical papers or preparing exhibits for presentation at meetings or presentation in the literature. AFMDC is always open to visitors and technical personnel are available to discuss various problems in detail and to show the User how AFMDC can assist his operation.

#### AFMDC User File Map (Figure 3, page 5)

The User File map shows the number of organizations per state and the total number of individual Users in those organizations per state. These figures include Industrial Firms, Government Agencies, Universities, Colleges, other Centers, Publishers and Societies. Four states have no Users and 21 states have 10 or less organizations. As would be expected, the heavy concentration of Users is in heavy industrial sections and the West Coast aerospace industry.

#### Distribution of AFMDC User File (page 6)

The basic User File was developed by using the following sources:

World Space Directory, Volume 3, No. 1 - This directory contains a large index of plants associated with the aerospace industry. An important section lists the "Major Missile and Space Manufacturers". Request forms were sent to key people in all of the company listings in this section, and provision was made in the form allowing for listing additional personnel, personnel from other divisions, and major subcontractors.

Manufacturing Committee of the Aerospace Industries Association Washington D.C. - This is an important aerospace group which has need for machining information in the solution of their common industry problems.

The American Society for Engineering Education (including members of the Engineering College Administrative Council, Engineering College Research Council, Technical Institute Council and Industrial Members) - Letters were sent to the deans of all of the important colleges which have significant interest in machining through departments such as: Aeronautical Engineering; Ceramic Engineering; General Engineering; Industrial Engineering; Mechanical Engineering Metallurgical Engineering; Pre-Engineering; Engineering Extension Groups; Control, Computer and Information Science Departments; Material and Engineering Sciences; and Technical Engineering Institutes and Engineering Research Groups oriented in disciplines of materials and material removal. Products of the Center have been helpful to college students, some of whom are already engaged in time standards work, manufacturing engineering, etc., in cooperative work programs and in summer jobs. Even more important is the fact that the training of engineers and thus their future professional performance will be influenced through AFMDC's activities.

Information Sources - Listings were compiled from "A Directory of Information Resources in the United States", National Referral Center for Science and Technology, Library of Congress, January 1965. The prime function of the Referral Center is to direct people to the proper information sources, including Centers, in the United States. Their directory contains a large listing of Centers, Technical Societies, Government agencies, etc., which in turn disseminate information to their various clientele. This directory was reviewed and selections for the User File were made.

1964 "ASM Index for the Review of Metal Literature" - This list includes societies and trade publications in the United States, and from it selections were made of those concerned with material removal.

Manufacturing Technology Division, Wright-Patterson AFB, Ohio, Report Distribution Lists - It should be noted that these distribution lists include other Departments of the Air Force, the Departments of the Army, Navy, Defense, and other Government agencies.

Inquirers - People who request information from AFMDC are termed 'inquirers'. New inquirers not already listed in the User File are added to it. Since there have been 3,315 inquiries during the 4 years operation of AFMDC, it is quite obvious that the file will grow considerably from this source alone.

Materials Advisory Board (MAB) Committee on Manufacturing Requirements for Aerospace Materials and the Ad Hoc Committee on Aerospace Manufacturing Requirements - This group was contacted because of its importance in manufacturing planning at a national level.

In order to keep the User File current, each individual on the User File is periodically contacted to ascertain whether he wishes to continue to be listed and whether there are any changes in position and address. The last such survey was accomplished in November 1967. Names are added to the User File as a result of: 1) inquirers, 2) visitors, 3) additional names submitted by current users, 4) requests resulting from dissemination of data products, and 5) technical articles published in periodicals and announcements pertaining to the Center.

Page 6 indicates that there are a total of 4,026 individual users from a total of 1,526 organizations.

#### Computer Input and Output Flow Chart (Figure 4, page 7)

The flow pattern described in this diagram gives a picture of the goals of AFMDC. All documents with detailed data are given to a Machining Data Analyst so that this data may be extracted and placed in "Data Code Forms", see Figure 5, page 8. This information is then punched on cards from which the disk files are generated.

8

The flow chart indicates Preliminary Technical Evaluation, a phase in document processing. While this step has been eliminated for incoming documents, it is shown because there is still a backlog in the files of documents which were processed as far as Preliminary Technical Evaluation prior to April 1, 1967.

Data Code Forms for Final Technical Evaluation (Figure 5, page 8)

Figure 5 is a photograph showing both the front and back of Data Code Forms used as an intermediate step between the original document and the punched cards used as input to disk storage. The formats are designed to handle alphameric information required for some parameters and decimal numbers for others, as well as integers. These formats and a book with codes enable the Machining Data Analyst to concisely identify the important information regarding a specific machining situation. Required decimals are set in the numerical data fields, thereby further simplifying recording of the data. These forms are then passed to the keypunch operator, who punches the information contained in them into Index, Tool-Cutting Fluid, and Numerical Data Cards.

These, plus the additional cards used by AFMDC are described as follows:

<u>Card</u>	<u>Description</u>
0 Inquiry	The Inquiry Card is punched with the inquiry information desired and is used by matching key indices in exactly the same columns as information which would have been precoded into the System.
1 Index	The Index Card establishes information available in the System by preassigned data index columns and respective codes to be matched against inquiries. This card describes the machining situation including the machining operation, specific material designation, hardness, condition, heat treatment, and broad material group. In addition to the above "minimum requirements", the Index Card also includes the part configuration code, tool material, machine tool description, and the control codes. The control codes provide information on the data source, its classification and index controls which allow for retrieval monitoring. The primary method of access into the AFMDC information decks is through the Index Card.
2 Tool-Cutting Fluid	This card defines tool size, shape, and geometry, as well as the trade name and manufacturer. It also identifies the trade name of the cutting fluid, the manufacturer, and the concentration of the cutting fluid.
3 Numerical Data	The Numerical Data Card contains actual values of machining variables, such as feeds, speeds, depth of cut, hole size, tool life, etc.



<u>Card</u>	<u>Description</u>
4 Uniterm (key word)	This card alphabetically describes special technical significance of a document not covered by categories included on the Index, Numerical Data, and Test-Testing Fluid Cards.
5 Data Link	This card provides means for eliminating the recording of data relevant to different topics or sources. Data are encoded and stored under one control code.
6 Aperture	The Aperture Card is used to store and retrieve microfilms of pertinent curves, drawings or any information best stored in a graphic manner.
7 Bibliography	The Bibliography Card set is designed to present the Source Document in a formalized, uncoded manner.
8 Potential Source of Information	This card records into the System information on contracts awarded and other work initiated or in progress which are considered potential information sources. In this manner, the card helps direct an active data acquisition program. It also serves as a card to store certain bibliographic information such as author and organization.
8 Visitor	This card has the same format as the Potential Source of Information Card and therefore serves not only to develop a Visitor File but can and is used to identify visitors as inquirers and/or potential sources of information.
9 Tickler	The Tickler Card is generated at the time machining information is committed to the System primarily as a review device for updating, purging, etc., but also for checking on commitments for potential sources of information. Dates for tickler review of data committed to the System are based upon the times related and shown in the Classification Code.

Flow Chart for Fortran Program to Store, Add or Search  
Inquiry File (Figure 6, page 9)

The flow chart of the inquiry program is an example of the storage and search techniques used by AFMDC on the IBM 1130 computer system. These programs have two basic sections: 1) to create files into which data may be stored, added to and deleted from, and 2) to set up a procedure for searching the data files. Discussion of the inquiry program follows:

- 1) Create data file and store additional cards to file. Console Data Switch No. 0 controls loading of a new deck of cards to create an original file. This file is created in a file protected disk area called "User Area". At the end of each month, inquiries for that month are coded and cards punched. The additional cards are then loaded at the end of the file. Console Data Switch No. 1 is used to control this function of the program. By this procedure, the Inquiry File is only one month behind any inquiry ever submitted to AFMDC.

- 2) Search Routine - Since the load and add functions of the program are to be bypassed, Data Switch No. 0 and Data Switch No. 1 are turned off. Control of the parameters to be matched in the search are then selected through the use of Data Switches No. 2, No. 3, No. 4 and No. 5. All or any combination may be selected by the operator as specified by the Machining Data Analyst. These Data Switches (D.S.) control matches for: Specific Machining Operation (D.S. 2); Specific Material Group (D.S. 3); Specific Material Description (D.S. 4); and Uniterm (D.S. 5). Through the use of the Data Switches the computer may be used to narrow the selection of documents if the initial search output yields too many references. This concept is fundamental to all of the search programs operated by AFMDC.

#### Inquiry File Search (Figure 7, page 10)

The Inquiry File which, as of September 30, 1968, contained data pertaining to 3,315 inquiries, is a very important AFMDC file. Search of this file can prevent duplicate effort in answering identical inquiries or provide assistance in answering those having similarity.

Figure 7 shows the use of Data Switches described in Figure 6, page 9, as they were utilized to make broad and then selective searches on the Inquiry File. The first search was made on the uniterm, CUT FLUID, by having Data Switch No. 5 in the 'on' position. When the file was interrogated the machine selected and printed all inquiries for which the uniterm, CUT FLUID, was used. To be more selective on the second search, material group 301 (NICKEL BASE HIGH TEMPERATURE ALLOYS) and material description INCOX750 were added to the CUT FLUID uniterm on the search card. In the third search, the machining operation requirement was added so that now the search was concentrated on a specific operation, on a specific material group, one specific material description and a uniterm requirement. From this type of search, the computer finds a precise match and prints that information. The number on the right is a unique number to that inquiry so the information may be reached quite rapidly.

#### Output of Preliminary Technical Evaluated Data (Figure 8, page 11)

Figure 8 shows a printout of a specific search on the Preliminary Index File.

The Preliminary Index File contains six possible terms which can be searched in any combination. Preliminary Technical Evaluation is designed to identify, if available, 1) machining operation, 2) material hardness, 3) material condition, 4) heat treatment, 5) material group, 6) material description, and 7) tool material. With the exception of material condition, an engineer may set up a search strategy to interrogate the file on any combination of the other six parameters. When a match is found, the source control code will be printed and the document pulled from the file. The Preliminary Index search shown in Figure 8 was made on an operation, DRILLING (085) of NICKEL BASE HIGH TEMPERATURE ALLOYS (material group 301).

#### Output of Uniterm File Search (Figure 9, page 12)

The uniterm concept was designed so that technical text important to material removal operations could be stored and retrieved. Each document is assigned uniterms (keywords) which describe the nature of the text. These uniterms are punched into cards which are stored on disks.

A second card is generated indicating the machining operations and material groups associated with the given uniterm. Thus, a selective search can be made linking a particular uniterm to a specific machining operation and/or a material group.

A master list of the uniterms is contained in the code book so that search strategies may be set up. A search can be made on a single term or on two terms simultaneously. These terms may be in any position within the card set. The search shown in Figure 9 is for the Uniterm, TOOL GEOMETRY (TOOL GEOM) for a given operation, DRILLING (085) of NICKEL BASE HIGH TEMPERATURE ALLOYS (material group 301). On the right hand side of the computer printout are the source control codes for the documents containing the desired information.

#### Output of Final Technical Evaluated Data (Figure 10, page 13)

Figure 10 is the computer printout of decoded information which has been extracted from a document which received Final Technical Evaluation. Note that the information extracted by the Machining Data Analyst and coded on the forms in Figure 5, page 8, is now computer decoded and printed out. The first line of data describes the inquiry to the file. The second line is the AFMDC match of the inquiry search terms on the stored Index card. The succeeding lines are the retrieved Tool Geometry, Tool Material, Cutting Fluid, and Numerical Data associated with the particular machining situation described in the Index card. The headings are printed and the retrieved information in the data cell is printed in the proper location. Coded integers are matched against another file on the disk resulting in the alphanumeric equal being printed on the output sheet. It is anticipated that this type of printout will be used to answer some inquiries directly later this year.

#### Cost Per Piece in Face Milling and End Milling. (Figure 11, page 14)

Equations have been written and computer programs have been developed and made operational for five major conventional chip removal operations. The particular operations are turning, milling, drilling, reaming and tapping. The equations developed for calculating machining costs in face milling and end milling are shown in Figure 11. Available representative hard data were processed using these computer programs in connection with a data product which has been developed on this subject.

#### Cost and Production Rate for Milling (Figure 12, page 15)

The use of data shown in Figure 10 leaves something to be desired for the manufacturing engineer. The printout gives a series of values to choose from but does not clearly indicate the economics involved. Since the major reason for having adequate data is to help minimize the cost, the logical question is which set of values will yield the minimum cost. A basic equation has been developed which considers the economics of each significant element of a machining operation and determines the production cost and production rate. The output gives the cost and production rate and the value of elements which make up the total cost. These values give the engineer an opportunity to analyze the elements so that he may decide where the major contributors to the total cost lie and then work on the critical areas.

#### Computer Printout for Investigating Relationships between Machining Variables (Figure 13, page 16)

Experience has shown that there are some relationships in machining variables between the various types of machining operations and work materials, and they can be determined if careful analyses are made using substantial and reliable data. Manual analyses of this type are difficult and cumbersome. Determination of existing relationships will be very valuable for evaluation of new data and filling in gaps in accrued data. AFMDC will investigate these relationships. The computer resolves much of the difficulty and time required to make the subject analyses. The computer program has very recently been made operational, and a considerable amount of reliable data is available in punched card form for processing. One of the initial sets of data run through the computer is shown in Figure 13, page 16. This is an extensive and worthwhile program.

#### Computer Printout of a Selective Search on Surface Integrity Bibliography File (Figure 14, page 17)

One of the subjects of highest interest to AFMDC inquirers as indicated in Figure 22, page 26, is Surface Integrity. Because of the large number of documents in AFMDC's storage on this broad subject and the wide variety of parameters within this subject, a computer program was developed and made operational to facilitate searching and listing specific bibliographic references from a separate disk file. The documents are coded according to operation, material description and scope of property topics. Searches may be made on up to ten codes within each parameter under any combination of "and" or "or" logic modes at either level. The search shown in Figure 14, page 17, is for the operation GRINDING (1), of material group TITANIUM ALLOYS (F), and property topics SURFACE CONDITION (A) or SURFACE FINISH (B) or RESIDUAL STRESS (C). A similar file has been set up for another subject of high interest, Numerical Control.

#### Computer Printout for Metal Removal Rates (Figure 15, page 18)

Considerable interest is being expressed through inquiries in metal removal rates for a wide variety of work materials. While the formulas used in calculating machining rates are not complex they are tedious and time consuming when performed using a slide rule or desk calculator. With a computer and the high amount of reliable machining data at AFMDC it is possible to make many valuable calculations in short order. These data are very useful in planning and setting up machining operations. A printout of machining data and calculations for turning, face milling and drilling are shown in Figure 15, page 18.

#### Cost Study Analysis of IBM 1130 Computer (page 19)

As a result of a request made by the Office of the Director of Defense Research and Engineering, Department of Defense, a cost study was conducted by AFMDC to determine the increase in effectiveness resulting from the installation of the IBM 1130 computing system. Prior to installation of the IBM 1130 computer the data processing equipment utilized was designated as an IBM Series 50 configuration. This consisted of a keypunch, verifier, sorter, collator and an electrical accounting machine.

A review was made of the various aspects of the AFMDC system and judgments made pertaining to those aspects which were affected, time-wise, by conversion from the IBM Series 50 configuration to the IBM 1130 computing system. It was judged the following aspects were affected: a) inquiry processing and b) calculations for production rates and machining costs.

The statistics shown on page 19 indicate that a savings of over \$13,000 for a one-year period was effected by installation of the IBM 1130 Computer. These important cost savings are the result of time saved by engineering and data processing personnel and are reinvested in the AFMDC operation. This is reflected in the continual and substantial rise in the ratio of output to input costs, thus providing more extensive services for the expended funds.

#### Inquiry Processing Flow Chart (Figure 16, page 20) Typical Inquiry Input and Response (Figure 17, page 21)

Responses to inquiries are the most important of the services provided by AFMDC. Strong emphasis is placed on providing specific and detailed answers to technical inquiries which are transmitted by letter, telegram, telephone or by direct visitation to the Center. A high percentage of the inquiries is made via telephone, some because of the urgency of information requirements and other due to the necessity of discussing technical details with the engineering personnel. When required, inquirers are contacted to clarify their specific needs. As indicated in

Figure 16, page 20, engineering personnel impose judgments on the inquiries and establish the search strategies. Data Processing personnel perform the computer search functions and provide the printouts to the engineers. The engineers again impose engineering judgment in the selection and preparation of the information to be transmitted to the inquirer.

An inquiry form and the AFMDC response are shown in Figure 17, page 21. Note the codes within the blocks on the form which are keypunched and then stored on the computer inquiry file.

#### Analysis of Inquiries by State (Figure 18, page 22)

The analysis of inquiries by state, Figure 18, page 22, provides some interesting and informative statistics. AFMDC has received inquiries from 42 states and the District of Columbia. Over the period October 1, 1964, through September 30, 1968, there have been 3,315 inquiries received and processed by AFMDC. These inquiries have originated from 1,138 different organizations and 1,928 individuals within these organizations. It is interesting to note that 80% of the total inquiries and 78% of the company and individual inquiries were from 10 highly industrial states, as would be expected. The specific inquiry statistics for these 10 states are shown in Figure 18, page 22.

#### Summary of Specific Inquiries by Type of Inquiry (Figure 19, page 23)

The statistics shown in Figure 19 point out several important factors. There has been a constant and substantial rate of growth in the number of inquiries received and processed at AFMDC. The average was 37 per month during the first 16-month period of the Centers operation. This average increased to 61 per month for the ensuing year and rose to an average of 84 per month the next 12-month period. During the last 8-month period the average increased to 123 per month. This growth has largely been the result of multiple inquiries from prior users, new contacts from companies already on the inquiry file and contacts from companies who have not previously submitted inquiries to AFMDC. Many of the new contacts can be attributed to "word of mouth" communication of AFMDC inquiries with persons who are in the field of machining.

Another factor responsible for this growth has been the AFMDC plant visitation program and participation in technical conferences.

In addition to providing information on the varied services available at AFMDC, Figure 19 indicates trends in the nature of inquiries from October 1964 to the present. In particular, it has been noted that inquiries are becoming more specific and are concerned with more complex and difficult machining situations. The relative increase in inquiry types 1, 2, 3, 15 and 16 bears out this conclusion.

The inquirer profile has also been relatively changing. A higher percentage of inquiries are being received at AFMDC from lower echelon personnel such as manufacturing or tool engineers, industrial engineers and time standards personnel, process engineers, tool designers, shop supervisors and foremen, planners, estimators, etc. This indicates that AFMDC is achieving its objective of reaching and setting up a direct line of communication with not only management, but also with an increasing number of persons directly responsible for application of machining data and information available from AFMDC.

General Analysis of Inquiries and Analysis of Inquiries by  
Material Group (Figure 20, page 24)

The chart, General Analysis of Inquiries, provides perspective of the relative complexity of inquiries, processed during the past 2-2/3 years. Of the inquiries related to given machining operations and material groups, over 75% were concerned with more than a single machining situation (one operation on one material group) for the past 2-2/3 years period. Over one-third of the inquiries were of the uniterm (keyword) type.

The Analysis of Inquiries by Material Group helps to provide AFMDC with perspective of user needs, input requirements, and establishes priority and extent of detailed technical evaluation of the input. An analysis of the past 2-2/3 years' inquiries was made categorizing the materials involved by 15 material groups. Figure 20, page 24, shows there has been a high level of interest for machining data on high temperature alloys, titanium alloys and refractory alloys. A high total of 1,336 requests was made for plain carbon and low alloy steels and ultra-high strength tool steels covering the 2-2/3 year period. Information for stainless steels was in high demand as evidenced in the 685 requests. The 120 requests, during the last 8-month period, for machining information on nonmetallics represented a significant increase over the 188 requests processed the previous two years.

Analysis of Inquiries by Type of Machining Operation  
(Figure 21, page 25)

Added perspective of user needs and in turn AFMDC input requirements is obtained by analyses such as shown in Figure 21. For conventional chip removal types of operations the statistics indicate that emphasis on input and detailed evaluation should be on turning, face milling, end milling, drilling, reaming, and tapping. The most significant relative increase in interest by type of machining operation within the 2-2/3 years has been in broaching and in band sawing. For conventional grinding, the highest interest is shown in surface and cylindrical grinding operations. The 250 requests for information on the alternate machining methods during the past 8-months represents a substantial increase over the 379 for the previous two years. These statistics are indicative of the increasing interests in these machining methods and alert AFMDC to an important area of its users' needs.

#### Analysis of Uniterm Type Inquiries (Figure 22, page 26)

A high percentage of the inquiries received at AFMDC are of the uniterm (keyword) type. This machining information is of the technical text type. The 17 subjects of highest interest for this type of machining information are shown in Figure 22, page 26. Very high interest has been expressed for information on surface integrity, numerical control, cutting fluids, surface finish and distortion. Very significant increased interest has developed during the 2-2/3 year period for information concerning surface integrity and surface finish.

#### Summary of Specific Inquiries by SIC Number (Figure 23, pages 27-30)

An analysis of inquiries by type of industry utilizing the services of AFMDC is shown in Figure 23. The chart presents the inquiries by SIC Code, a number which references listings in the Standard Industrial Classification Manual, Executive Office of the President, Bureau of the Budget, 1967. While some SIC descriptions may appear completely commercial, an analysis of specific inquiries will indicate a close relationship to DoD requirements, as shown in Figure 24, page 31.

SIC Major Group No. 37, Transportation Equipment, is the predominant group with respect to utilizing AFMDC services. This group encompasses three significant industry users of AFMDC, namely: Aircraft and Missiles; Aircraft Engines and Engine Parts and Missile Engines; and Aircraft Parts and Auxiliary Equipment and Missile Parts. Other SIC Major Groups who provided relatively high quantities of inquiries to AFMDC during the past year are: 91 - Federal Government; 33 - Primary Metal Industries; 34 - Fabricated Metal Products Except Ordnance, Machinery and Transportation Equipment; 35 - Machinery, Except Electrical; 36 - Electrical Machinery Equipment and Supplies; 73 - Miscellaneous Business Services; 82 - Educational Services.

#### Government Agencies and Services Supported Directly and Indirectly by AFMDC Inquiries (Figure 24, page 31)

The data shown in this chart are somewhat difficult to compile but by careful analysis of particular inquiries and by an analysis of the prime objectives of principal contractors at various plant locations it has been possible to show that 935 of the 982 requests made to the Center were stimulated by Air Force, AEC, U.S. Navy, NASA, and U.S. Army projects.

#### Companies and Agencies Submitting Inquiries to AFMDC (Figure 25, pages 32-40)

#### Summary of Specific Inquiries by Companies Making Five or More Requests (Figure 26, page 41)

Figure 25 presents a total of 1,138 individual companies and divisions which have been inquirers of AFMDC, an increase of 228 organizations



during the last 8-month period. These are listed on pages 39 and 40 of Figure 25. This is a comprehensive list. Figure 26 includes a summary of the 129 organizations (including the divisions) making five or more requests. This group has provided 2,149 of the 3,315 inquiries processed by AFMDC to date. This list reflects high interest in AFMDC information on the part of aerospace industry, as represented by companies such as Aerojet-General Corporation, the Boeing Company, Curtiss-Wright Corporation, General Dynamics Corporation, General Electric Company, Grumman Aircraft Engineering Corporation, Lockheed Aircraft Corporation, Martin Company, McDonnell Douglas Corporation, TRW Inc., and in fact Wright-Patterson Air Force Base itself.

Photograph of AFMDC Data Products (Figure 27, page 42)

Photograph of AFMDC Titanium Booklet (Figure 28, page 43)

Typical Formats for Data Presentations (Figure 29, page 44)

Planned data products have proven to be important output to AFMDC Users. In addition to providing valuable and timely data, these products serve as a direct line of communication with the Users of the Center. Excellent response has been received for the 13 data products prepared and issued to date. Some of these products are shown in the photo in Figure 27, and the formats are displayed in Figures 28 and 29. Careful thought was given to the preparations of the products to present the machining recommendations in complete but concise form in order to make easy and effective use of them.

Description and Distribution of AFMDC Data Products (Figure 30, page 45)

There were two primary means used for publicizing the data products. AFMDC prepared three separate data product announcements and sent them to the User File which now consists of 4026 individual names. The policy followed was to provide one free copy to Users who submitted a request and then charge for additional copies. The set limit of making 1000 free copies available proved to be practical inasmuch as all requests from the User File were able to be filled. A second means used for reaching persons who would have an interest in the data products was accomplished by sending copies of these documents to about 60 editors of technical periodicals. Each of these were encouraged to publish announcements of the products and print typical data sheets. This not only stimulated interest in the data products, but also in the Center's services in general. Numerous inquiries were submitted to the Center each time a periodical published the information provided by AFMDC.

The fine response for data products is indicated in Figure 30, page 45. A total of 16,047 copies were distributed, most of which were to the User File and some as direct response to inquiries. The 2833 copies sold are further evidence of the high interest and use of the data products.

#### Data Acquisition Plant Visit Program (page 46)

During the previous contract period 46 plants were visited for the purpose of acquiring machining data from them on a regular basis. Emphasis was placed on visiting aerospace firms. Visits to all plants were satisfactory and there was general interest in this project. Nearly all the plants have taken steps to make necessary arrangements for transmitting data. Over 300 reports of high data yield have already been received from these plants. Follow up is being made in the form of correspondence and periodic visits.

During all visits detailed information was provided concerning AFMDC's organization and how it functions. Effort was made to reach directly or through responsible supervisory personnel the lower echelon manufacturing and manufacturing engineering people who need data for immediate application to machining of hardware. The effect of this approach was noted in the significant increase in inquiries received from most of the companies visited.

#### Code Sheet for Project Time Cards (Figure 31, pages 47 and 48)

##### AFMDC Daily Time Slip (Figure 32, page 49)

##### Computer Printout of AFMDC Project Time Cards (Figure 33, page 50)

The code sheet provides the basic approach to AFMDC System Costing. Approximately 100 individual time codes are in current use. It has been simple for individuals to maintain time records because relatively few time codes are used by any one person during a given day and the use of the same codes is repeated from day to day. Figure 32, page 49, shows a Daily Time Slip which indicates the manner in which individuals record their time.

The information from these time slips is punched into cards and the information is stored in the IBM 1130 computer. Figure 33, page 50, is a computer printout of AFMDC project time cards.

Figures 34 and 35, shown on pages 51 and 52, reflect the use made of project time card data. These records are available for making even more detailed analyses when required. For example, it would be possible to analyze the cost for a particular project, such as a special report requested by DoD.

#### AFMDC OPERATING COSTS (Figure 34, page 51) AFMDC INPUT AND OUTPUT SUMMARY (Figure 35, page 52)

Figure 34, page 51, shows the operating costs for the past eight months broken down into five major groups: 1) Input, 2) Output, 3) General

Dissemination, 4) Reports and 5) Systems Analysis, Modification and Control. A summary of these costs follows:

SUMMARY OF AFMDC OPERATING COSTS  
FEBRUARY 1, 1968 - SEPTEMBER 30, 1968

<u>Major Group</u>	<u>Cost</u>	<u>% of Total Cost</u>
Input	64,935.33	36.3
Output	79,271.53	44.3
General Dissemination	3,199.41	1.8
Reports	18,440.32	10.3
Systems Analysis, Modification and Control	13,308.61	7.3
Total Operating Costs	\$179,155.20	

It is significant to note that the output costs represent 44.3% of the total operating costs. This is considered to be a relatively high figure for an information analysis center.

The chart in Figure 35, page 52, presents various summaries of AFMDC input and output. As of September 30, 1968, there were 15,941 evaluated documents in AFMDC's storage. The important information from these documents has been extracted, coded, and punched into 116,083 cards, and stored on the IBM 1130 Computer. Unit costs for preparation of 11 data products and for processing of inquiries are cited in Figure 35, page 52.

Future Planning (pages 53 and 54)

One of the major goals for the next year is to continue the effort to identify and make direct contacts with personnel in all echelons who can utilize machining information available from the Center. The methods used to accomplish this are outlined under Future Planning, pages 53 and 54. Emphasis will be given to contractors, subcontractors and sub-sub-contractors producing components for advanced aerospace vehicles. The approaches to be taken will undoubtedly stimulate inquiry activity and thereby continue the upward trend in inquiries being received by AFMDC. It is expected that the level of inquiries will reach a monthly average of about 160 per month by October 1969 (the average for the past eight months is 123). The program of plant visitation will be continued with increased emphasis on making the industrial user aware of the information at AFMDC which is available to him.

A considerable number of inquiries have been received from active State Technical Services Programs in California, Connecticut, Georgia, Illinois, Indiana, Iowa, Michigan, Ohio, Tennessee and West Virginia. In addition, AFMDC has directly participated in conferences and meetings

conducted by the states of Illinois, Indiana and Michigan. Contacts will be made with other states which have such programs in operation or are in the process of setting up such programs. Fine coordination has been effected with the National Referral Center as well as various information centers. Communication with these centers will be maintained.

AFMDC was chosen to participate in a Special Merit Project with the State of Vermont, along with another DoD Information Analysis Center, namely, PLASTEC. Included also in this cooperative effort is the Vermont Office of Technical Services, and the University of Vermont Technical Information Center, Office of State Technical Services.

The purpose of this proposed program is to evaluate for one year, on an experimental basis, the feasibility of referring Vermont industries and business to selected Federal Information Analysis Centers for answers to their technical questions.

The overall objectives are: 1) to establish access to appropriate information analysis centers through the University of Vermont Technical Information Center and 2) to test the information transfer relationship between individual companies (requesting information), information analysis centers, and the Technical Information Center (acting as a coupler).

The results of this pilot project will be of interest to states similar to Vermont in size and technical problems. The results will also be of interest to other information analysis centers who might have a potential cooperative role in similar information services.

The office of State Technical Services, Washington, D.C. is setting up a program in the State of New York, similar to the one in Vermont, and AFMDC will be the only information center in that study.

The Foreign Technology Division (FTD), Wright-Patterson Air Force Base, is interested in various information analysis centers make more extensive use of their foreign literature holdings. Also they feel that these centers could materially assist in the dissemination of this information to the centers' users. AFMDC plans to establish closer coordination with FTD and assist them in their objectives.

There has been substantial growth in vocational schools, as well as vocational courses offered by educational institutions. Many of these include training of students in machining who thereby become an important segment of the machining community. AFMDC will expand its services to these schools through the State Technical Services Programs and by direct contact.

Efforts on data products will be directed toward preparation of the four products listed under Future Planning since information seems to be lacking or widely scattered on these subjects.

Additional data products will be prepared as good timely information is accrued by AFMDC.

Experience has shown that there are some relationships in machining variables between the various types of machining operations and work materials, and they can be determined if careful analyses are made using substantial and reliable data. Manual analyses of this type are difficult and cumbersome. Determination of existing relationships would be very valuable for evaluation of new data and filling in gaps in accrued data. AFMDC is investigating these relationships. The computer resolves much of the difficulty and time required to make the subject analyses.

Preliminary discussions have been held with one aerospace firm concerning an experimental program of a computer data-link between the company and AFMDC. In this experimental program it is planned that mechanisms would be developed that would allow a firm to have direct communication with the Center's computer. This communication would make it possible for the user to directly submit and obtain an immediate response. The direct link with the user would facilitate machining information formats which would be compatible between the Center and the major users. A part of the planned program is to work out procedures whereby an organization could store its important machining data at AFMDC for its own rapid retrieval and for utilization by AFMDC for serving industry.

#### Potential for AFMDC Services to Industry (Figure 36, page 56)

The statistics shown in Figure 36 indicate that five major SIC Groups provide a vast potential for utilization of AFMDC services and they have been the primary groups submitting inquiries to AFMDC. The left-hand side of the chart, Figure 36, provides a statistical summary of metalworking plants consisting of a partial SIC list taken from Dun & Bradstreet Metalworking Directory, 1967-68. The right-hand side of the chart summarizes AFMDC inquiries for the same SIC classifications.

As would be expected, the largest number of inquiries have been received from Major Group 37, Transportation Equipment. Four of the SIC Industrial Classifications within this group are: 3721 - Aircraft and Missiles; 3722 - Aircraft Engines and Parts; 3723 - Aircraft Propellers and Propeller Parts; and 3729 - Aircraft Parts and Auxiliary Equipment. A second significant source of inquiries is Major Group 35, Machinery Except Electrical. Some of the important industries included in this group are Machine Tools-Metal Cutting Types, Machine Tool Accessories and Measuring Devices and Machine Shops - Jobbing and Repairing. The statistics from Dun & Bradstreet's Metalworking Directory display a vast economic environment for AFMDC operations. Metalworking is the prime activity for five major groups alone, comprised of 9,431 companies (20 or more employees), employing 6,900,557 individuals. There are 20,063 other companies (20 or more employees), for which metalworking is a secondary activity. Dun & Bradstreet reports that 21,364 of the 38,383 listings in its Metalworking Directory perform machining operations. Although no specific statistics can be quoted, there is no doubt that there is even a larger number of firms (employing less than 20 individuals), whose major activity is machining. Considering that to date there has been a total of 910 organizations which have submitted inquiries to AFMDC speaks for itself regarding the potential increase in services that is possible to the machining industry.

#### COST SAVINGS RESULTING FROM AFMDC OPERATION (Figure 37, page 57)

The base used for estimating cost savings resulting from AFMDC's operation is a machining situation which is defined as a specific material removal operation being used on a specific material with definite chemical, physical or mechanical properties. There are many specific parameters that make a machining situation complex. The parameters include: machining operation, work material and its metallurgical and physical characteristics such as, microstructure, hardness, strength, modulus of the elasticity, etc., the part configuration, dimensional and surface finish tolerances, the machine tool being utilized, tool material, tool geometry, cutting fluid, cutting speed, feed and tool life.

This inherent complexity of a machining situation naturally reflects itself in a high cost required to develop the proper combination of parameters needed to effectively perform a given machining operation.

Several members of the AFMDC staff have had direct and extensive experience in the development and application of machining data, particularly in aerospace plants. A major part of the experience has been in increasing productivity of existing machining operations, establishing effective machining parameters for new production operations and solving problems being encountered on critical operations.

It has been the experience of the staff members of AFMDC that the selection of the proper combination of machining parameters can result in major cost savings. The most common method practiced in arriving at a workable set of conditions is that of 'hit or miss'. This is a costly method and manifests itself in high expenditure of time, broken cutting tools, costly scrapped parts, and schedule delays. One alternative is the systematic generation of the required machinability data in a machinability laboratory or on a production machine. This method is effective but also time consuming and costly. Ofttimes, production schedules do not permit the required time.

The consensus of these AFMDC staff members is that the dollar value of a set of recommended parameters for one machining situation given in response to an inquiry is very conservatively \$800.00, and usually runs into thousands of dollars. Thus, the \$800.00 value assigned in the cost analysis for a set of evaluated parameters applicable to a specific machining situation is indeed ultra conservative. This is particularly true in the case of a specific inquiry for which there is almost invariably an immediate need for reliable data.

For the purposes of this report a value of \$300.00 was assigned for the cost saving resulting from the application of one set of data utilized from an AFMDC data product. Each data product issued from the Center was in response to an AFMDC data product announcement, or was sold. A relative few were used in response to an inquiry in those cases where the data product was directly applicable. It is reasonable to assume that each individual who received an AFMDC data product had a need for some portion of the published data. Each of the data products contain hundreds, and in some cases thousands, of recommendations for machining situations. In the cost analysis presented in this report it has been assumed that only the one individual who received the data product used it. Further, it was assumed that he applied only five machining situations from the product. These assumptions are most conservative.

Very conservatively it has been estimated that a total of \$37,800,000.00 cost savings to AFMDC users has resulted from the operation in four years. These savings are attributed to the Center's response to specific inquiries and its data products. Figure 37, page 57, presents the pertinent statistics used to make the aforementioned estimated cost savings. Considering the total funds made available to AFMDC during this 4-year period, for each dollar expended there was a return of \$47.00 in effected cost savings. If the services provided by AFMDC were not available, the cost to the Government and industry would by far exceed the \$37,800,000.00 figure. This conclusion was substantiated by examples provided by industry of the value of the Centers' services and cited in an AFMDC report, "Cost Savings Resulting From The Operation Of The Air Force Machinability Data Center", July 29, 1968.

Considerable value must also be placed on what timely and reliable machining information has on eliminating or minimizing production delays. It is not possible to assess dollar values for such cases, but significant emphasis should be placed on the impact of production delays. Another value of reliable machining data that is extremely difficult to place in terms of dollars is its importance on the quality and integrity of machined parts. The majority of companies involved in machining do not have proper facilities or capability to develop good reliable machining data. Those that generate this data do so at a very high cost, very often at the expense of the Government.

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13. ABSTRACT This is the Fourth Annual Report of the Air Force Machinability Data Center covering period February 1, 1968 through September 30, 1968 (Contract AF 33(615)-5262). Two thousand eight hundred and forty (2,840) documents were processed from which 13,833 cards were key punched. Currently, there are 15,941 evaluated documents and 116,083 punched cards in AFMDC files. Nine hundred and eighty two (982) specific inquiries were answered for 439 different companies, representing 596 individuals in 105 different SIC categories. The average of 123 inquiries per month is an increase of 46% over the average of 84 per month processed in the previous year.  The average cost of inquiries equaled \$58.58 per inquiry.  Two data products were completed and made available to the Center's users.  The data acquisition plant visit program was continued and since late 1966, 46 Visitations have been made, primarily to aerospace firms.  Computer programs have been developed and made operational for storage and retrieval of all the information files in use by the Center. In addition, a computer program has been made operational for investigating relationships between machining variables. Determination of existing relationships will be very valuable for evaluation of new data and filling in gaps in accrued data.			

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